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Application for reservations of water in



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APPLICATION FOR RESERVATIONS OF WATER  
IN THE MISSOURI RIVER BASIN  
ABOVE FORT PECK DAM

Summary, Purpose, Need, Amount,  
Public Interest, Management Plan,  
Appendices and Attachments

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## INTRODUCTION

Section 85-2-331, MCA authorizes this application from the headwaters to Fort Peck Dam. This application contains the Summary, Purpose, Need, Amount (including details of methods used), Public Interest Considerations, and a Management Plan as required by ARM 36.16.104 through 36.16.106.

This reservation request is based on the need to protect water users by minimizing the degradation of water quality which will result from further consumption of water in the Missouri River Basin. The primary constituent which contributes to degradation of water quality in the Missouri River Basin is arsenic. The safe drinking water Maximum Contamination Level (MCL) of 50  $\mu\text{g/l}$  (ARM 16.20 et seq) is commonly exceeded throughout the Madison River. Concentrations of arsenic in the Madison and the Missouri River mainstems exceed the acceptable level for carcinogens which has been adopted by the Montana Board of Health and Environmental Sciences (BHES) as a surface water quality standard.

For purposes of this application, that portion of the Missouri River Basin above Canyon Ferry Dam is sometimes referred to as the "upper" Missouri Basin and that portion between Canyon Ferry Dam and Fort Peck Dam as the "middle" Missouri basin.

## SUMMARY

Pursuant to Section 85-2-316, MCA, and Article II of the Constitution of the State of Montana which establishes that a clean and healthful environment is an inalienable right of Montana citizens, the Montana Department of Health and Environmental Sciences (DHES) respectfully files application for reservations of water in the Missouri River Basin above Fort Peck Dam. Section 85-2-331(1), MCA, requires that water reservation applications for the basin below Fort Peck Dam be submitted by July 1, 1991.

Figure 1 is a Missouri River Basin map showing where the requested reservations will be applied to use.

The prevention, abatement, and control of pollution in state waters is the responsibility of the Montana Department of Health and Environmental Sciences through 75-5-211, MCA. The 1973 Water Use Act provides the opportunity for the state or any political subdivision or agency thereof or the United States to apply to the Board of Natural Resources and Conservation to reserve waters for existing or future beneficial uses or to maintain a minimum flow, level or quality of water (Section 85-2-316, MCA).

The Department of Health and Environmental Sciences is charged with "protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses;" (75-5-101 (1) MCA). Water reservations for instream flows will serve to protect and maintain water quality thus protecting the public health and thereby assist in meeting those responsibilities.

Reservations are not requested for specific tributaries. Flows are requested for the mainstems of the Madison and the Missouri rivers. Specific requests are submitted only for stations on the Missouri River. In order to satisfy these requests, some flows will have to be reserved on tributaries as well. Specific tributary flows are not requested. The specific requests are set forth later in the "Analysis of the Amount of Water Necessary for the Purpose of the Reservations."

There are attached hereto, and made a part hereof, statements on the purpose of, the need for, amount of, and public interest of these requested reservations of water. These statements and their attachments are presented in support of this application for reservations of water and to meet the requirements of the Montana Water Use Act and applicable rules thereunder for the establishment of reservations of water for protection of water quality.

THIS APPLICATION CONTAINS NO PROPOSED PROJECTS FOR CONSUMPTIVE USE OF THE RESERVED WATER.



## PURPOSE OF THE RESERVATIONS

Section 85-2-102, MCA, and ARM 36.16.102 define beneficial as "... includes the maintenance of a minimum flow, level, or quality of water..."

The purpose of these reservations is to reserve flows for existing and future beneficial uses and to minimize increases in risks to the public health which will be caused by increased consumptive uses in the basin.

The beneficiaries of the reservations will be the those people who rely on the Madison and the Missouri rivers and groundwater replenished by these streams for their source of drinking water.

Maintaining flows in stream channels also benefits those persons who now divert water from the Madison River for irrigation by decreasing the rate at which soils accumulate arsenic and extending the time during which products produced by this irrigation will have arsenic levels low enough for human consumption. Other persons who divert water will also benefit by having a known minimum flow at their diversion points. This will ensure that the diversion structures will not require rebuilding in order to function at lower flows. Those persons holding discharge permits will also benefit by having a known amount of dilution water.

## ANALYSIS OF THE NEED FOR THE RESERVATIONS

The major public health benefit of the DHES reservation is its role in protecting municipal and private water supplies. Many people in the Missouri Basin utilize surface water or shallow, streamside aquifers as their drinking water sources. At the present time concentrations of arsenic in the Madison River exceed the drinking water standards, and due to the high concentrations of arsenic in the Missouri River mainstem and the Boulder River, there are significant risks associated with consuming these waters because of their carcinogenic effects. The reservation would help limit the increases in concentrations and would thus serve to protect the public health.

High concentrations of arsenic originate from geothermal sources in Yellowstone National Park and enter the Missouri River drainage via the Madison River (U. S. Geological Survey, 1987a). Tributaries to the Madison and Missouri rivers dilute arsenic concentrations, lowering concentrations downstream. The U. S. Geological Survey (USGS, 1987b) measured arsenic concentrations of 200 to 300 micrograms per liter (ug/l) in the upper Madison River and concentrations of 20 to 40 ug/l in the Missouri River upstream from Canyon Ferry Reservoir (at Toston). Human health concerns exist because the allowable limit for arsenic in drinking water is 50 ug/l total recoverable arsenic [U. S. Environmental Protection Agency 1986, ARM 16.20.203(1)(a)]. The U. S. Environmental Protection Agency (EPA) is planning to lower this limit, which is based on toxicity, not on carcinogenicity, to some number in the 20 to 30 ug/l range (1989, C. Ris, U.S. Environmental Protection Agency, Washington, D.C., personal communication).

Data collected by the U. S. Geological Survey (USGS) in 1985 and 1986 (U. S. Geological Survey 1987a), show that arsenic concentrations exceed the present drinking water standards in the Madison River below Hebgen Lake (e.g., 78 to 180 ug/l), below Ennis Lake (49 to 100 ug/l), and at Three Forks (45 to 87 ug/l). Arsenic concentrations in the Missouri River at Toston ranged from 22 to 40 ug/l and below Canyon Ferry Reservoir from 22 to 34 ug/l. Arsenic concentrations in the Boulder River at it's mouth averaged about 20 ug/l but because of the relatively small discharge the average load was only about 18 pounds per day. Arsenic loads remained essentially constant at about 800 pounds per day measured below Hebgen and below Canyon Ferry Dams.

The USGS data collected in 1987 indicated that arsenic concentrations also exceeded the drinking water standards in the entire Madison River, ranging from 78 to 150 ug/l below Hebgen Reservoir to 42 to 85 ug/l at Three Forks. Arsenic concentrations in the Madison River above Hebgen Reservoir averaged 237 ug/l during the 1987 sampling period. During this short spring period arsenic loads averaged about 400 pounds per day in the Madison River below Hebgen Reservoir and about 390 pounds per day in the Missouri River near Landusky, During this

period flows at both of these stations averaged about one-half of the long term mean (USGS, 1987b). This indicates that the amount of arsenic in the stream was essential constant and the amount of dilution determines the arsenic concentration in the Madison/Missouri River mainstems. Of course any changes in the amount of storage in the mainstem reservoirs will change the amount and thus the concentration of arsenic in the stream. The effects of changes in storage, evaporation, and dilution are discussed in the section on the DETERMINATION OF THE AMOUNT OF THE RESERVATION.

The Jefferson and Gallatin rivers, which do not have high arsenic concentrations, are normally major diluters of the arsenic concentrations in the Madison River. A water sample collected by the USGS on August 17, 1988 (a drought year) at Toston contained 100 ug/l dissolved arsenic (at least twice the EPA drinking water standard). The previous maximum concentration recorded from 58 samples collected at that site since 1972 was 52 ug/l. The mean concentration of all 58 samples was 24 ug/l (1989, R. Knapton, U.S. Geological Survey, Helena Montana, personal communication).

Extremely low stream flows prevailed throughout Montana in 1988, including the Jefferson and Gallatin Rivers. On August 17, 1988, the flow in the Jefferson River was only 52 cfs (8% of the long-term daily mean flow) and the Gallatin River value was at 60% of its long-term mean daily flow (1989, R. Knapton, USGS, Helena Montana, personal communication). This lack of streamflow for dilution caused the increased concentration of arsenic at Toston on August 17, 1988, illustrating the importance of adequate instream flows to prevent increases in arsenic concentrations.

Although it is widely known that arsenic is toxic, it is not generally known that arsenic is a carcinogen. In 1984 the EPA estimated the "upper bound" or maximum risk of excess skin cancer for lifetime exposure to arsenic in drinking water (EPA, 1984). In 1987 the EPA re-examined this issue and developed different maximum risk estimates (EPA, 1987). Both risk estimates are shown in Table 1. At the maximum contaminate level of 50  $\mu\text{g/l}$ , which is allowed in public drinking water supplies, both by federal and state law, the increased cancer risks are 21,500 and 2,500 per million people exposed for the 1984 and the 1987 estimates, respectively.

Table 1

Arsenic concentrations in drinking water and the  
resulting risk of skin cancer

Arsenic mg/l	<u>Skin cancer risk / million</u>	
	1984 est 1/	1987 est 2.
0.001	430	50
0.005	2,150	250
0.010	4,300	500
0.015	6,400	750
0.020	8,600	1,000
0.050	21,500	2,500
0.100	43,000	5,000

- 1/ Because these risks which are based on the current official EPA criteria and state standards appear to be relatively large, EPA has reexamined this issue. In 1987 they convened a Risk Assessment Forum consisting of the world experts on the relationship between arsenic and skin cancer.
- 2/ Risk of skin cancer based on the Risk Assessment Forum's results. This Forum concluded that although arsenic definitely does cause skin cancer, the previous (and still official as of December, 1988) risk values were too high. They also noted that arsenic does cause internal cancers but that they were unable to calculate these risks because of a lack of data.

The Montana Board of Health and Environmental Sciences (BHES) has adopted the "Gold Book" levels for water and fish ingestion (EPA, 1986) in the Montana Surface Water Quality Standards (16.20.601 et seq). For carcinogenic substances these levels are based on an increased cancer risk of one excess case of cancer per million people exposed. For arsenic, the risk estimates adopted by the state of Montana correspond to the 1984 EPA estimates. Although the estimated excess cancer cases for these estimates are shown in Table 1 the remainder of this application is based on the more recent EPA estimates which will undoubtedly be adopted by the state after they are formally adopted by the EPA. The natural concentrations of arsenic in the Madison/Missouri River mainstems cause the cancer risk to exceed the one per million people exposed standard which has been adopted by the BHES regardless of which estimate is used. However, the standards are adopted to prevent the activities of man from interfering with the beneficial uses of water. For arsenic, a concentration of 1  $\mu\text{g/l}$  will cause an increased cancer risk of 50 cases per million people exposed based the most recent EPA estimates. The concentration of arsenic in the Missouri River exceeds 1  $\mu\text{g/l}$  all the way to the North Dakota boundary.

As used here "risk" is the probability of contracting cancer due to ingesting water containing arsenic. Risk values range from zero, which means cancer will not result, to one, which means that cancer will surely result. Of course, there are many things which will cause cancer, so risk as used herein actually means excess or increased risk.

All activities result in some risk. Some risks can be calculated based on historical data. For instance the lifetime risk of death due to motor vehicle accidents, falls and home accidents can be calculated based on the number of deaths in a representative year, the total number of people in the United States, an average lifespan of 70 years, and assuming the number of deaths per year will remain constant. These risks are 1/65 (.015), 1/186 (.0054), and 1/130 (.0077) for motor vehicle accidents, falls, and home accidents respectively (Hutt, 1978). A major unstated assumption in calculations of this type is that all people are equally at risk. Although this is not true for most cases, because of a lack of sufficient data this simplifying assumption is usually required.

The risk estimates for most carcinogens are based on animal studies where relatively high levels of the suspected carcinogen are applied to animals for their life time. The effects of this application are then extrapolated to lower levels and applied to humans. This is not the case for arsenic. The risk estimates for excess cancer caused by ingesting arsenic are based on observed relationships between consumption of water containing

various concentrations of arsenic and the occurrence of cancer in humans.

The major source of this data is a series of studies done in Taiwan by several investigators (Tseng, 1968; Tseng et al, 1977). These studies involved a study population of 40,421 people who were exposed to drinking water with arsenic concentrations ranging from 10 to 1820  $\mu\text{g/l}$  and a control population of 7500 people whose drinking water contained arsenic concentrations ranging from below the detection level to 17  $\mu\text{g/l}$ . Four hundred and twenty eight cases of skin cancer were found in the study group (a rate of 10.6 cases of cancer per 1000 people). No cases were found in the control group. The lack of any excess cases in the control group, despite its exposure to some arsenic, was possibly due to the small size of this group (EPA, 1988). The youngest individual with skin cancer was 24 years old. The Risk Assessment Forum (EPA, 1988) concluded that arsenic also causes internal cancers, but that it was unable to develop risk estimates because "the technical panel has no data on dose-response".

The mean arsenic removal efficiencies for the public water supplies using Missouri River water were calculated using the means of 12 samples collected during 1987 (Table 2). These values together with the mean instream arsenic concentrations were used to calculate that the current arsenic levels may be causing up to 41 excess cases of cancer in the people using these supplies (table 3). There are no public water supplies using Madison River water. However, there are private water supplies in the Madison River Valley that have about 170  $\mu\text{g/l}$  of arsenic which result in risk levels of about 1 excess cases of cancer per 100 people (Table 2).

Table 2  
Arsenic in Water Supplies  
in the Madison/Missouri River System

Location	Source 3/	<u>Arsenic Concentration</u>		Percent Remaining
		Raw µg/l	Potable µg/l	
Three Forks	GW	2-3	2-3 1/	0
Townsend	GW	1-8	1-8 1/	0
BOR-Canyon Ferry	SW	26	21	80
Helena	SW	22	9	35
Great Falls	SW	20	8	40
Carter	SW	17	17	0
Fort Benton	GW	Insufficient data		
Fort Peck	SW	3	3	0
Madison Valley Groundwater above Three Forks		up to 170		
Missouri Valley Groundwater in Toston		up to 25		

1/ No Treatment

2/ Includes some removal between the Missouri River and the sampling point

3/ GW = Ground water    SW = Surface water

Table 3

Estimated maximum excess life time cancer risk (U.S. EPA, 1987) due to present arsenic concentrations in public water supplies in the Missouri River Basin

Location	Arsenic 1/ Concentration µg/l	Individual Cancer Risk	Population Served 2/	Life time Cases
Three Forks	3	.00015	1,180	.177
Townsend	8	.00040	1,600	.640
BOR Canyon Ferry	22.8	.00110	100	.110
Helena	10.0	.00050	12,000 3/	5.988
Great Falls	9.3	.00046	72,000	33.280
Carter	16.9	.00084	220	.186
Fort Benton 4/	Insufficient data			
Fort Peck	3	.00015	500	.075
TOTAL CASES				40.456

1/ Mean values of 7 samples of treated water collected between March and June 1987

2/ From DHES files

3/ Average population served by the Missouri River supply

4/ Concentration of present well is not yet adequately known, previously the concentration averaged 10 µg/l

Although virtually all of the arsenic in the rivers comes from thermal discharges in Yellowstone National Park (YNP), there are also elevated arsenic concentrations in the Boulder River. For the one complete year of data which exists (USGS, 1987a) the flow weighted mean concentration is 20  $\mu\text{g/l}$  and the load is 18 pounds per day. The actual sources of this arsenic have not been investigated but it is known that arsenic is usually associated with sulfide mineral deposits, such as occur in the Basin area and that the highest arsenic concentrations (up to 260  $\mu\text{g/l}$ ) in the Boulder River occur between the towns of Boulder and Basin (DHES, files). Two surface (0-4 inches) soil samples collected in 1989 had total arsenic concentrations of 331 and 378  $\mu\text{g/l}$  (DHES, files). In the area where the sample had 378  $\mu\text{g/l}$  the soil was barren of vegetation.

Concentrations of arsenic in the Madison River at the park boundary exceed 200  $\mu\text{g/l}$  and these levels are diluted to about 25  $\mu\text{g/l}$  in the Missouri River at Toston (this corresponds to a risk of 1250 cases per million people exposed). At the discharge from Ft. Peck Reservoir, the concentration is about 3  $\mu\text{g/l}$ . Although some arsenic is removed by conventional water treatment the increased risk of cancer for the Missouri River water portion of the Helena and Great Falls waters systems is about 500 per million people (Tables 1 and 3).

The load of arsenic (tons per year) appears to be essentially constant from Yellowstone National Park to Fort Peck Reservoir. Because the amount of arsenic in the river is constant, any reduction in the discharge of streams tributary to the Madison or Missouri Rivers will increase the concentration of arsenic in the Madison and the Missouri Rivers and increase the cancer risk to people drinking the water. At the present time arsenic concentration in the shallow near stream aquifers have been measured at up to 76  $\mu\text{g/l}$  near Cameron and at about 25  $\mu\text{g/l}$  in Toston (DHES, files).

Use of Madison or Missouri River water for irrigation will probably result in some increase in the concentration of arsenic in the groundwater and cause an increase in the cancer risk for people using that groundwater as a source of drinking water. This has occurred in the Madison River Valley above Three Forks. In fact, of the 65 wells sampled in this area by John Sonderegger, more than 40 of them have arsenic concentrations which exceed the drinking water standard of 50  $\mu\text{g/l}$  (Sonderegger and Sholes, 1989, Sonderegger and Ohguchi, 1988). The maximum value was over 150  $\mu\text{g/l}$ . At those concentrations it is possible that symptoms of chronic arsenic poisoning may be present in some of the people (1989, E. King MD, Gallatin Count Health Officer, Belgrade, Montana personal communication). The increased cancer risk due to arsenic concentrations in some of those wells is 7.3 per 1000 people exposed.

The EPA has estimated that use of water containing 100  $\mu\text{g/l}$  of arsenic for irrigation for 100 years on some soils could result in a 50 % reduction in the yield of "sensitive crops" (the sensitive crops were not listed) (EPA, 1972). Arsenic concentrations in the Madison River exceed 100  $\mu\text{g/l}$  above Ennis and at times approach 100  $\mu\text{g/l}$  at Three Forks. Thus it is possible that the production of some crops has already been reduced. In addition it has been demonstrated that crops grown in soils enriched with arsenic tend to accumulate arsenic.

The amount of arsenic present in irrigated crops grown in the Madison/Missouri River Valleys have not been determined but it is probable that they contain greater than normal amounts. In addition to accumulating arsenic from soil and the soil solution it appears that some plants absorb arsenic through their leaves. This absorption has been demonstrated to occur near sources of airborne arsenic such as at East Helena (DHES, files). Thus it is reasonable to assume that sprinkler irrigation with water containing high concentrations of arsenic will elevate the concentration of arsenic in crops.

The U.S. Food and Drug (FDA) Administration has established a tolerance level of zero for arsenic in fruit and vegetables sold in interstate commerce. When the arsenic concentration exceeds zero the FDA sets action levels on a case by case basis so that the excess cancer risks do not exceed 10 per million people exposed. The United States Department of Agriculture (USDA) has set action levels for arsenic concentrations in meat products as follows; beef, meat 0.5 parts per million (ppm), liver 2.7 ppm and, pork and poultry, meat 0.5 ppm and liver 2 ppm. If the action levels are exceeded the products can not be sold for human consumption (DHES, files). The concentrations of arsenic that are present in crops and animals grown in the Madison/Missouri River basin are not known, but any increase in the concentration of arsenic in the rivers can be expected to increase the present levels.

As has been noted above, any increase in water withdrawal from streams which are tributaries to the Madison or Missouri rivers will cause an increase in the concentration of arsenic in the mainstems. Therefore, any existing irrigation water from the Madison, Missouri or Boulder rivers is likely to result in increased contamination of the local groundwater.

Under existing Montana statutes a water right for instream beneficial use, in this case, for the maintenance water quality, can only be obtained by applying for a reservation and not by petitioning or applying for a water use permit. Without these requested reservations, the beneficial uses provided for by Montana law cannot be protected.

Existing water rights in the river basin will at all times

be honored. If the requested reservations are not granted, any waters available over and above such existing rights will be vulnerable to future appropriations by permit. If these future appropriations are allowed to be executed in advance of, or without, the reservations being established, the water quality of the waters will be permanently degraded to the detriment of the public health and will impair other beneficial uses of these waters. It is apparent that under our current laws and regulations, waters once allowed to be appropriated might never again be available for reservation, thus there is a need for an adequate reservation.

Low flow conditions will reduce the amount of water available for dilution of industrial and municipal discharges, and non-point pollution. Current and future industrial and municipal waste discharge permits could be affected by chronic low flows.

## DETERMINATION OF THE AMOUNT OF THE RESERVATIONS

The methods used to derive the flow quantities requested for each stream reach in the application are based on the need to protect the public health, which would require that DHES request all of the water in the basin, and 85-5-331 MCA which limits instream reservations to one half of the mean annual flow on gauged streams.

Also discussed in this section is the water availability information required by ARM 36.16.105B(2).

Arsenic in the Madison and Missouri River systems originates primarily from the geothermal waters of Yellowstone National Park (USGS, 1987a). These geothermal waters originate deep below the earth's surface and maintain a relatively constant flow and concentration. Surface flows tend to dilute the concentration of arsenic in the system but do not appreciably change the load.

This assumed constant output of arsenic from YNP will be affected by storage and release in the reservoirs. The amount of arsenic passing any downstream point at any particular time will depend on the amount of water that is being released from storage and the amount of water coming from good quality tributaries. Determining the amount of water that is stored and released from the various reservoirs and their effects on arsenic concentrations is beyond the scope of this analysis. Fortunately there is instantaneous data on arsenic concentrations at different points in the system over time. This information was used to estimate the mean daily load of arsenic in the Madison/Missouri river mainstems (Table 4). Furthermore, the calculated loads reflect the actual operation of storage reservoirs and future reservoir operations should have similar effects.

Table 4 - Arsenic Concentrations and Loads in the Madison and Missouri Rivers.

Location	Period of Arsenic Observations	Number of Observations	Arsenic Concentrations ug/l	Mean Flow CFS 2/	Load lbs/day
Madison River below Hebgen Lake 06038500	9/85 - 9/87 1/	26 1/	127 1/	1005	784
Missouri River near Toston 06054500	3/73 - 9/82 2/	39 2/	27	5876	856
Missouri River at Virgelle 06109500	3/73 - 9/82	22	15	9625	779
Missouri River at Landusky 0611520	7/76 - 8/82	21	15	10191	825
Missouri River below Ft. Peck 06132000	4/75 - 8/82	18	4	8967	216

1/ From DHES records

2/ Calculated for the period arsenic observations using USGS flows.

3/ From Storet

Mean arsenic loads were calculated from instantaneous concentration data and the corresponding flows for representative stations on the Madison and Missouri rivers (Table 4). Values for these calculations were obtained from STORET (EPA) and the Water Resources Data-Montana (USGS) for concentration and flow, respectively. Note that the loads from Hebgen to Landusky are relatively constant at approximately 800 pounds per day. Because the contribution of the Boulder River is small (about 20 pounds per day) relative to the 800 pounds per day load of the Madison, the inputs from the Boulder will be ignored in the discussion which follows.

By using the estimated load of 800 pounds per day and the mean flows for the period 1937 to 1987, provided by USGS, the mean arsenic concentrations at various stations were calculated (Table 5).

Table 5. Calculated and observed total recoverable arsenic concentrations at mean and one-half mean annual flows for selected stations.

	Mean Annual			One-half Mean	
	Discharge (cfs)	Arsenic Calculated (ug/l)	Arsenic Observed (ug/l)	Discharge (cfs)	Arsenic (ug/l)
Madison River below Hebgen Lake 06038500	1028	144	140	514	288
Missouri River at Toston 06054500	5193	29	31 3/.26 2/	2596	57
Missouri River at Ulm 06078200	6409	23	20 3/	3204	46
Mirrouri River at Virgelle 06109500	8779	17	15	4390	34
Missouri River at Landusky 06115200	9631	15	15	4815	31

- 1/ Based on Storet data unless otherwise noted.
- 2/ Observed concentrations (USGS, 1987a and USGS, 1987b)
- 3/ Observed as part of drinking water study March-June 1987.

DHES' maximum reservations on gauged streams is limited to one half of the mean annual flow. These flows and the resulting estimated arsenic concentrations are shown in Table 5. For comparative purposes the present mean annual flows and arsenic concentrations are also shown in Table 5.

It should be emphasized that the carcinogenic effects of arsenic exposure result from the total amount of arsenic ingested over a long period of time. Daily or monthly changes in the arsenic concentration are relatively unimportant as long as potentially toxic values, the drinking water limit of 50  $\mu\text{g/l}$ , are not exceeded.

The total expected number of increased cases of cancer which would result from depletion to one half of the mean annual flows are 82 which 2 times the present number. DHES realizes that it is unlikely that sufficient water will be consumed to reduce flows to one half of the present mean annual flow. Nevertheless, it is possible that given sufficient time this situation could occur.

Strictly speaking, the affects of depletion on arsenic concentrations which are discussed above apply only to depletions from good quality tributaries. The affects of depletions from the Madison or the Missouri are much more difficult to estimate. Water withdrawn from these streams also contains arsenic. For some unknown period of time an amount of arsenic will be retained by the irrigated soils and in the groundwater.

Irrigation has been occurring in the Madison Valley above Three Forks for about 100 years and the concentration in the groundwater is apparently still increasing. (1989, John Sonderegger, Montana Bureau of Mines and Geology, Butte, Montana, personal communication) This indicates that arsenic is still being stored in the area and that all of the arsenic removed with the irrigation water is not being returned with the recharge water. Unfortunately it is not possible to predict the amount of arsenic which will be returned and how long it will be retained. Consequently, for the purposes of this reservation application, it is assumed that all depletions occur on good quality tributaries and that no additional withdrawals will occur from the Madison River.

Based on the observed concentrating effects in the Madison Valley above Three Forks, we can expect the groundwater under other such areas to ultimately have arsenic concentrations up to three times the arsenic concentrations of the diverted water. In the case of diversions from the Madison River this could result in arsenic concentrations which exceed the drinking water standards and an increased cancer risk of 1 case per 100 people. In the Missouri River valley the increased cancer risk would probably be the major effect.

In addition, as the increased number of cancer cases resulting from increases in arsenic concentrations in public water supplies there will also be increases in the risks associated with consuming water from the shallow stream side aquifers whose arsenic concentrations will also increase to some degree. DHES has not estimated the number of people who may be affected by changes in groundwater quality.

To illustrate the effects of the depletion of water due to irrigation the increased cases of cancer which would be expected to result from increased arsenic concentrations in public water supplies resulting from new irrigation of 10,000 acres above various points were calculated. In these calculations it was assumed that all depletions occur on good quality tributaries and that the depletions result in a decrease in the mean flow throughout each year at all water supplies below Toston, and Ulm. The conversion of acres irrigated to decreases in mean flows was done by DNRC Staff (1989, D. DeLuca, Montana Department of Natural Resources and Conservation, Helena, Montana, personal communication).

These calculations were performed for irrigation above Toston, Ulm, Virgelle, and Landusky. In each case all of the 10,000 acres were assumed to be above one of these points and the resulting decrease in flow was projected to all of the downstream points. The new arsenic concentrations at each public water supply intake was converted into an increased number of excess cases of cancer by assuming that the present arsenic removal efficiency of each treatment plant remains constant (Table 2).

The number of excess cases of cancer that can be expected due to the new irrigation of 10,000 acres above Toston, between Toston and Ulm and, between Ulm and Virgelle are shown in Tables 6, 7, and 8, respectively. Because there are no public supplies withdrawing water from the Missouri River between Virgelle and Landusky and because these estimates are only for public water supply systems, no calculations are presented for the increased risks in this reach. This does not mean that there are no risks associated with withdrawal of waters tributary to this reach. Similarly, there will be additional increased of cancer association with private wells which are located in some streamside aquifers due to irrigation withdrawals in the reaches but these risks have not been estimated.

Table 6

Estimated maximum excess life time cancer risk (U.S. EPA, 1987) due to arsenic concentrations in public water supplies in the Missouri River Basin resulting from irrigation of an additional 10,000 acres above Toston

Location	Arsenic 1/ Concentration µg/l	Individual Cancer Risk	Population Served 3/	Life Time Cases
Three Forks	3 2/	.00015	1,180	.177
Townsend	8 2/	.00040	1,600	.640
BOR Canyon Ferry	22.9	.00115	100	.115
Helena	10.0	.00050	12,000 4/	6.014
Great Falls	9.3	.00046	72,000	33.396
Carter	16.9	.00095	220	.209
Fort Benton	Insufficient data			
Fort Peck 4/	3	.00015	500	.075
TOTAL CASES				40.626

1/ After treatment

2/ From DHES files

3/ Average population served by the Missouri River supply

4/ Arsenic concentration assumed to be constant

Table 7

Estimated maximum excess life time cancer risk (U.S. EPA, 1987) due to arsenic concentrations in public water supplies in the Missouri River Basin resulting from irrigation of an additional 10,000 acres between Toston and Ulm

Location	Arsenic 1/ Concentration µg/l	Individual Cancer Risk	Population Served 3/	Life Time Cases
Three Forks	3 2/	.00015	1,180	.177
Townsend	8 2/	.00040	1,600	.640
BOR Canyon Ferry	22.8	.00110	100	.110
Helena	10.0	.00050	12,000 4/	5.988
Great Falls	9.3	.00046	72,000	33.396
Carter	16.9	.00095	220	.209
Fort Benton	Insufficient data			
Fort Peck 4/	3	.00015	500	.075
TOTAL CASES				40.595

1/ After treatment

2/ From DHES files

3/ Average population served by the Missouri River supply

4/ Arsenic concentration assumed to be constant

Table 8

Estimated maximum excess life time cancer risk (U.S. EPA, 1987) due to arsenic concentrations in public water supplies in the Missouri River Basin resulting from irrigation of an additional 10,000 acres between Ulm and Virgelle

Location	Arsenic 1/ Concentration µg/l	Individual Cancer Risk	Population Served 3/	Life Time Cases
Three Forks	3 2/	.00015	1,180	.177
Townsend	8 2/	.00040	1,600	.640
BOR Canyon Ferry	22.8	.00110	100	.110
Helena	10.0	.00050	12,000 4/	5.988
Great Falls	9.3	.00046	72,000	33.280
Carter	16.9	.00095	220	.209
Fort Benton	Insufficient data			
Fort Peck 4/	3	.00015	500	.075
TOTAL CASES				40.479

1/ After treatment

2/ From DHES files

3/ Average population served by the Missouri River supply

4/ Arsenic concentration assumed to be constant

Any new irrigation of 10,000 acres can be expected to result in only .170, .139 and .023 (Tables 6, 7, and 8) additional excess risks of cancer in the people served by public water supply systems if the irrigation occurs above Toston, between Toston and Ulm, and between Ulm and Virgelle, respectively. The increase resulting from new irrigation between Ulm and Virgelle is undoubtedly an overestimate as much of any new irrigation will probably occur in the Marias Basin. This irrigation will not affect the arsenic concentration at any of the listed public water supplies. Of course it does not make sense to talk about a fractional increase in cancer cases, one either has or does not have cancer. The numbers are presented so that the affects of any amount of irrigation above or between any of these points can be calculated using simple mathematics; if the affects of irrigation of 20,000 acres above Toston are desired the estimates is simply double the .170 given for 10,000 acres or .340. If an estimate of the affects of irrigation throughout this basin is desired it is simply a case of adding the estimates for each point i.e., if an estimate of the affects of 10,000 acres of new irrigation in each section is desired the correct estimate is  $.170 + .139 + .023$  or .332 (Tables 6, 7, and 8).

## AMOUNT OF WATER REQUESTED

Based on the forgoing discussion the DHES requests that the one-half the mean annual flows listed in Table 5 be reserved to maintain water quality at the following points; Missouri River at Toston, Missouri River at Ulm, Missouri River at Virgelle, and the Missouri River at Landusky. If the water which makes up these flows in the Missouri originate disproportionately from the Madison or the Boulder rivers the number of excess cases of cancer will be greater than discussed in the preceding section. It should be born in mind that even with this reservation there could be an additional 40 cases of cancer in the users of public water supplies due to new consumption of water in the basin.

Although the DHES is limited by 75-5-311 MCA to the flows listed above, any reservation or appropriation of water which result in a depletion in the average flow of the Madison or Missouri Rivers will technically violate the Montana Surface Water Quality Standards (16.20.618 (h) and the Montana Nondegradation Rules (16.20.701 et seq). These two sets of rules taken together prohibit increases in the concentration of substances for which there are drinking water limits (16.20.618 (h)(i) and for "deleterious substances". Arsenic clearly falls in both categories. Since any depletions will cause an increase in the arsenic concentrations in the Madison and Missouri Rivers and will result in an increase in the expected number of cancers in the population which is dependent on these rivers for their drinking water supply any such depletions will technically violate state law.

## Water Availability

ARM 36.16.105B(2) requires the applicant to determine the physical availability of flows. Statistical information must include the monthly mean flows and the 20th, 50th, and 80th percentile exceedance frequency flows on a monthly basis throughout the year. A summary of these flows, at the requested reservation points, is attached as appendix A.

Through a cooperative agreement, the Montana Department of Fish Wildlife and Parks contracted with the Helena office of the USGS to obtain this for all gauged points. The completed work will be published as a USGS technical report entitled "Monthly Streamflow Characteristics for Selected Sites in the Upper Missouri River Basin, Montana, 1937-86 Base Period" by Charles Parrett, J.A. Hull, and Dave R. Johnson.

At the time this application was completed, the final report had not yet been officially released by the USGS. However, the derived streamflow contained in the report are presented in Appendix A of the reservation application prepared by the Montana Department of Fish Wildlife and Parks. The final report will be forwarded to the Board upon receipt. Any corrections to the data will also be brought to the Board's attention.

## The Reservation is in the Public Interest

These reservations of water are in the public interest. The public benefits which will accrue from the reservation are:

1. minimizing the increase in the risk of cancer to people drinking water from the Madison or Missouri rivers or from aquifers near the river which are recharged by water from these streams will be minimized;
2. minimizing in the area in which groundwater will be contaminated by irrigation water rich in arsenic;
3. Minimizing the rate at which soils and crops are being contaminated by irrigation with water rich in arsenic;
4. maintenance of water quality which contributes to a clean, healthful environment for the citizens of the state and the nation; and
5. contribution to the protection of and continued utilization of existing water rights.

A showing that the reservations are in the public interest, including their direct and indirect benefits and costs, is provided in the discussion which follows.

### I. Direct Benefits and Costs of the Reservation

The following is pursuant to ARM 36.16.105 c(1)(a) of the water reservation rules:

In making a showing that the reservation is in the public interest, the application shall contain . . . an analysis of the direct benefits and costs associated with applying reserved water to the proposed beneficial use.

Direct benefits and costs are defined at ARM 36.16.102 (6) and (7) as:

- (6) Direct benefits mean all benefits to the reservant derived from applying reserved water to the use for which it is granted, and

the following sections describe the public benefits and costs of the reservation requested by the DHES.

- (7) Direct costs means all costs to the reservant from applying reserved water to the beneficial use for the purpose granted.

#### A. Direct Benefits of the Reservation

The requested reservation will minimize the increases in arsenic concentrations which will result from future depletions and thus protect the public health by minimizing the number of excess cancer cases due to consumption of water containing arsenic. DHES has not attempted to quantify the monetary costs of doubling the present number of excess cancer cases which could be expected to result even if the reservation is granted. Similarly the costs of incremental increases in the number of excess cancer case has not been quantified. However the reservation will limit the expected number of increased excess cases of cancer. If the reservation is not granted there is no limit to the number of increased cancers which may result.

#### B. Direct Costs of the Reservation

Treatment of Drinking water on an individual household basis is an alternative to partially solve the public health problems posed by the high arsenic concentrations in the basins water. Individual treatment units cost about \$500 initially and require about \$200 per year in maintenance costs. Thus, assuming 100,000 people need treated water then 33,000 units (3 people per unit) would be needed. The initial cost of treatment could be as much as \$16,500,000 with a continuing yearly cost of \$6,600,00. Providing treatment at public water supply systems is not likely to reduce these costs. Treatment plants typically provide 170 gallons of water per day per person. Only about one half gallon of this is actually used for drinking water.

Some stream reaches of the Missouri River Basin do not have gauges at appropriate locations to adequately monitor streamflows. Once reservations are granted, monitoring of streamflows on some unguaged stream reaches may be necessary for protection of the granted flows. This may require installation of additional stream gauges or relocation of existing gauges. The costs of installing gauges would range from \$600 to \$17,500 per gauge, depending on the level of technology required for adequate monitoring (Karp, 1987). Annual operating costs would range from \$800 to \$5,500, depending on the complexity of the monitoring program (Karp, 1987). Until details of the reservation granted to DHES are known it is not possible to determine if any new gauges will be required.

Other direct costs are those associated with DHES's inhouse operations to implement whatever program is required to protect the granted reservations. Specific cost information cannot be provided at this time.

## II Indirect Benefits and Costs of the Reservation

Indirect benefits and costs, are defined in ARM 36.16.102 (12) and (13), as:

- (12) "Indirect benefits" means the benefits of applying reserved water to beneficial use that accrue to other uses or to parties other than the reservant" and,
- (13) "Indirect costs" means the costs of applying reserved water to beneficial use that accrue to other uses or to parties other than the reservant.

For the purpose of this application "indirect," therefore, refers to "uses or to parties other than" DHES, and the DHES reservation will be the means "of applying reserved water to beneficial use."

The following is pursuant to ARM 36.16.105C(1)(a) of the water reservation rules:

In making a showing that the reservation is in the public interest, the application shall contain . . . A discussion of the indirect benefits and costs associated with applying water to beneficial use that considers the following:

- (i) future economic activity, (ii) the environment, (iii) public health and safety, and (iv) the economic opportunity costs that the requested flow may have to parties other than the reservant.

The economic considerations of these requirements, subsections (i) and (iv) are discussed below under A. Effects of the Reservation on Future Economic Activity, and under C. Economic Opportunity Costs of the Reservation. The indirect economic benefits of the reservation are covered in A., while indirect economic costs, including foregone opportunity costs, are addressed in C. Non-economic considerations, as per sections (ii) and (iii) above, are presented in B., Effects of the Reservation on the Environment, Public Health, Welfare and Safety.

When establishing and prioritizing water reservation requests, a major criterion utilized by the Board of Natural

Resources and Conservation (BDRC) is an evaluation of the effects that a reservation may have on "other uses or parties." The following discussion, therefore, presents the effects upon municipal, agricultural and industrial water users.

#### A. Economic Benefits to Other Users or Parties

##### 1. Municipalities

Municipalities would benefit from the DHES reservation because of increased assurances about the future availability of high quality drinking water. Maintenance of instream flow levels would, in turn, sustain water levels at city intake structures and infiltration galleries. If incremental streamflow depletions were to continue, as they have occurred in the past, relocation of these supply structures and/or development of alternative water supplies could be necessary. Either of these alternatives would be costly for the municipalities involved.

##### 2. Industry

Hydropower is a major beneficiary of the DHES reservation. Eleven hydroelectric facilities in the Montana portion of the Missouri Basin, including five near Great Falls, along with Holter, Hauser, Toston, Ennis, Canyon Ferry and Fort Peck dams, annually produce about 3.7 million megawatt hours of electricity (DNRC 1986). Nearly half of this electrical energy is produced at Canyon Ferry and Fort Peck dams.

Maintaining instream flows through a water reservation would provide monetary benefits through electrical generation at existing, publicly-owned facilities. Water that is available in the Missouri River Basin not only passes through the Bureau of Reclamation's Canyon Ferry Dam and the U.S. Corps of Engineers' dam at Fort Peck, it also powers five other major hydropower generating facilities owned by the federal government in North Dakota and South Dakota. Table 9 presents the average generating capacity of each facility and the cumulative electrical generation per acre-foot of water as it passes from one facility to the next.

Table 9. Kilowatt Hour (kWh) Generation Per Acre-foot (AF) of water (Median Water or Most Probable Runoff).

Power Plant	Average Generation (kWh/AF)	Cumulative (kWh/AF)
Canyon Ferry	125	125
Fort Peck	164	289
Garrison	148	437
Oahe	154	591
Big Bend	56	647
Fort Randall	95	742
Gavins Point	35	777

Source: Western Area Power Administration, January 20, 1984.

There are varying concepts of how water in streams and reservoirs are most appropriately valued. Both the Western Area Power Administration (WAPA) and the U. S. Army Corps of Engineers (Corps) have provided estimates of the value of an acre-foot of water for hydropower in the Missouri River Basin. The value of an acre-foot of water passing through the 7 hydropower facilities would depend on the sale price of electricity. According to WAPA, the price of electricity ranges from 7.5 mils per kilowatt hour (kWh) for "firm" power to 14 mils per kWh for "surplus" power (Schirk, 1987). Based on the cumulative generation of electricity through the Missouri River mainstem dams (Table 9), the value of an acre-foot of water would range from \$5.83 to \$10.88.

The indirect economic benefit of the DHES reservation to the nine hydroelectric facilities in the Montana portion of the basin is also significant. When the price of electricity, as quoted by the WAPA (Shirk, 1987), is applied to the electrical production rates at these Montana facilities, the value of wholesale power produced ranges from \$27,800,000 to \$51,800,000 per year (i.e., 3.7 million megawatts per year x 7.5 to 14 mils per kilowatt hour). These estimated values are conservative. Roughly one-half of the hydroelectric power production in the Missouri Basin in Montana is from private facilities, which typically receive a much higher sale price for their electricity (Dodds, 1989).

Velehradsky (1987) provided a slightly lower estimate for the value of electrical production at the Corps' Missouri River facilities (\$4.90/acre-foot). However, he also stated that the perceived benefits of hydropower are much greater than any current production estimates. If new power sources must be brought on line, the cost could be 60 mils per kWh or higher, or equivalent to about \$41.00 per acre-foot.

The instream flows requested in this application and those required for existing hydropower facilities are mutually supportive, as long as water release schedules from these dams are closely tied to the needs of fish and water-based recreation. The reservation would help maintain the electrical generating capacity of the hydropower plants on the Missouri River, which currently provide some of the most economical electrical power in the western states.

The DHES reservation would also help stabilize industrial waste treatment costs. Maintaining instream flows in the Missouri River Basin would help provide sufficient water volumes to dilute and assimilate wastewater discharges from existing facilities. DHES only issues discharge permits to waste treatment facilities where there are sufficient streamflows to dilute the wastes. Each discharge permit has criteria attached specifying that receiving waters would be protected as long as streamflow does not fall below the 7-day, 10-year low flow limit for a given stream. (The 7-day, 10-year low flow is the lowest flow that would occur at a probability of once every 10 years for a consecutive 7-day period.) If the flow of receiving water falls below the 7-day, 10-year limit, waste discharges would not necessarily be curtailed, but the biological and chemical integrity of the streams would no longer be protected.

Instream flow reservations would help prevent streams receiving wastewater discharges from dropping below the 7-day, 10-year low flow limit established to prevent water quality degradation and damage to aquatic ecosystems. If flows should be depleted below minimum levels to provide adequate dilution and assimilation of wastewater discharges, prevention of damage to aquatic ecosystems would only be avoided by suspending the discharge of wastewater to streams. Preventing already permitted facilities from discharging wastes during these periods could pose serious operational and economic consequences. Either treatment facilities would need to be upgraded to reduce the quantity of various chemical compounds and organic materials in wastewater, or effluents would have to be disposed of on land or through some other means. Such measures would be extremely expensive. Preventing damage to aquatic ecosystems through maintenance of instream flows would be more cost effective than upgrading waste treatment facilities or land disposal of wastewater.

Municipalities would also be recipients of the above indirect economic benefit of the reservation, since there are nearly as many permitted municipal sewage treatment plant dischargers in the Missouri Basin (43) as there are industrial dischargers (46). All of the Montana Pollution Discharge Elimination System (MPDES) permitted facilities in the Missouri Basin that receive benefits associated with stabilized instream flows/waste treatment costs are listed in Table 10.

Table 10. Montana Permit Discharge Elimination Systems--  
Municipal, Industrial, and Placer Mine Permits.

<u>Permittee</u>	<u>County</u>	<u>Receiving Water</u>	<u>Permit Expiration Date</u>
<u>Municipal Permits</u>			
Dillon	Beaverhead	Beaverhead River	01-31-89
Townsend	Broadwater	Missouri River	05-31-93
Belt	Cascade	Belt Creek	01-31-89
Great Falls WTP	Cascade	Missouri River	05-31-92
Great Falls	Cascade	Missouri River	09-30-92
Village Water & Sewer	Cascade	Sun River	03-31-93
Vaughn	Cascade	Sun River	12-31-89
Big Sandy	Chouteau	Big Sandy Creek	10-31-88
Geraldine	Chouteau	Flathead Creek	05-31-93
Chouteau/ Highwood	Chouteau	Highwood Creek	01-31-89
Fort Benton WTP	Chouteau	Missouri River	05-31-89
Fort Benton WTP	Chouteau	Missouri River	08-31-91
Denton	Fergus	Wolf Creek	01-31-89
Lewistown	Fergus	Big Spring Creek	01-31-89
Willow Creek Sewer	Gallatin	Unnamed Drain Ditch	07-31-90
Bozeman	Gallatin	East Gallatin River	05-31-93
Three Forks	Gallatin	Madison River	10-31-89
Manhattan	Gallatin	Gallatin River	09-30-92
Cut Bank	Glacier	Cut Bank Creek	05-31-93
Browning	Glacier	Depot Creek/ Willow Creek	05-31-86
Whitehall	Jefferson	Jefferson River	12-31-89
Hillbrook Nursing Home	Jefferson	Prickly Pear Creek	03-31-89
Boulder	Jefferson	Boulder River	03-31-89
Hobson	Judith Basin	Unnamed Drainage	09-30-88
Stanford	Judith Basin	Skull Creek	05-31-91
Helena	Lewis & Clark	Prickly Pear Creek	05-31-91
US BOR Canyon Ferry	Lewis & Clark	Missouri River	08-31-89
US BOR CF Govt Camp	Lewis & Clark	Missouri River	08-31-89
Helena WTP	Lewis & Clark	Prickly Pear Creek	09-30-91
East Helena	Lewis & Clark	Prickly Pear Creek	05-31-91
Sheridan	Madison	Mill Creek	03-31-89
Ennis	Madison	Madison River	09-30-88
White Sulphur Springs	Meagher	Lone Willow Creek	05-31-93
Valier	Pondera	Unnamed Dry Creek Bed	11-30-89
Conrad	Pondera	Marias River	07-31-89
Brady Water Users	Pondera	South Pondera Coulee	05-31-93
Choteau	Teton	Teton River	01-31-89

Fairfield	Teton	Freezeout Lake	05-31-93
Dutton	Teton	Hunt Coulee	05-31-93
Toole/Sweetgrass	Toole	Unnamed Dry 1. Bed	05-31-93
Sunburst	Toole	Unnamed Dry 1. Bed	01-31-90
Shelby	Toole	Marias River	05-31-93
Fort Peck	Valley	Missouri River	05-31-93

### Industrial Permits

Anaconda Minerals	Cascade	Missouri River	02-28-89
Janetski, Lee B.	Cascade	Missouri River	06-30-90
Antonioli, Mrs. P.	Cascade	Squaw Creek	12-31-89
MPC-Rainbow	Cascade	Missouri River	06-30-89
MPC-Black Eagle	Cascade	Missouri River	06-30-89
MT Refining Co.	Cascade	Missouri River	07-01-88
MPC-Ryan	Cascade	Missouri River	06-30-89
Genco Industries	Cascade	Belt Creek	07-31-92
Blue Range Mining	Fergus	Big Spring Creek	10-31-89
Blue Range Eng.	Fergus	East Fork Fords Creek	09-30-91
Sourdough Cr Prop	Gallatin	Various	08-31-91
Ideal Basic Ind.	Gallatin	Missouri River	02-28-91
Beren Corp.	Glacier	Unnamed Slough	06-01-91
Flying J, Inc.	Glacier	Spring Coulee	05-31-93
Corbin Water Usrs	Jefferson	Corbin Creek	05-31-91
Boulder Ht Sprngs	Jefferson	Little Boulder River	05-31-92
MT Tunnels Mining	Jefferson	Trib. to Spring Creek	10-31-91
Pangea Mining	Jefferson	Basin Creek	05-31-93
Pangea Mining	Jefferson	Monitor Creek	05-31-93
Ash Grove Cement	Jefferson	Prickly Pear Creek	12-31-89
Gulf Titanium	Lewis & Clark	Jennies Fork	09-30-91
Black Hawk Mining	Lewis & Clark	Banner Creek	09-30-90
Clark, Dexter	Lewis & Clark	Spring Creek	12-31-92
MT Gold & Saphre	Lewis & Clark	Missouri River	06-30-88
MPC-Holter	Lewis & Clark	Missouri River	06-30-89
MPC-Hauser	Lewis & Clark	Missouri River	06-30-89
Century Silver	Lewis & Clark	Ten Mile Creek	08-31-92
Liquid Air Corp.	Lewis & Clark	Prickly Pear Creek	12-31-89
Uncle Sam Mines	Madison	Middle Fork Mill Crk	04-30-92
U.S. Grant Gold	Madison	Alder Creek	01-31-92
Rocky Mt. Mnrls	Madison	Rochester Creek	05-31-89
Red Pine/Shermont	Madison	Indian Creek	02-28-90
MT Talc	Madison	Johnny Gulch Creek	09-30-92
Cyprus Ind. Min.	Madison	Middle Fork Stone Crk	07-31-89
MPC-Madison	Madison	Madison River	06-30-89
Denimil Resources	Madison	Pony Creek	12-31-89
Cyprus Ind. Min.	Madison	Sweetwater Creek	05-31-93
Zortman-Landusky	Phillips	King Creek	10-31-91
Zortman-Landusky	Phillips	Various	10-31-91
Malta Ready Mix	Phillips	Milk River-Dodson Cnl	05-31-93
Western Reserves	Toole	Unnamed Closed Basin	07-31-89
Texaco, Inc.	Toole	Stockponds	10-31-88
Silver Fox Oil	Toole	Ephemeral Drainage	04-01-89
A & G Oil & Gas	Toole	Stockponds	04-30-88

East. Am. Energy	Toole	Unnamed Coulees	12-31-87
Devon Water, Inc.	Toole	Tiber Reservoir	11-30-88

### Placer Mines & Suction Dredges

Golden Star	Beaverhead	Big Moosehorn Creek	09-90
Golden Star	Beaverhead	Ruby Creek	09-90
Golden Star	Beaverhead	Little Moosehorn Crk	09-90
Miragliotta, Vito	Beaverhead	Jeff Davis Creek	08-88
Searle Bros.	Beaverhead	Jeff Davis Creek	03-93
Towner, Bob	Beaverhead	Grasshopper Creek	07-89
Wright, Alan	Broadwater	Indian Creek	03-92
Klies, Forrest	Jefferson	Jack Creek	10-90
Klies, Forrest	Jefferson	Basin Creek	10-90
Jefferson Creek	Lewis & Clark	Jefferson Creek	06-86
Holzworth, Dick	Lewis & Clark	Skelly Creek	03-88
Modern Expl., etc.	Lewis & Clark	Prickly Pear Creek	12-92
Morris, Bud	Lewis & Clark	Hauser Lake	05-93
MT Gold & Saphr	Lewis & Clark	Missouri River	06-88
Fredriksen, etc.	Lewis & Clark	Missouri River	12-92
Sypult, Cleatus	Lewis & Clark	Madison Gulch	10-90
Placer Recovery	Lewis & Clark	Jefferson Creek	02-93
Brown's Gulch	Madison	Brown's Gulch Creek	09-86
Parker, Rodney	Madison	Barton Gulch	06-90
Lince, Carol G.	Madison	California Creek	08-92

Source: Montana Department of Health and Environmental Sciences, Files, Helena, Montana, 1988.

Last, and very important, the diversity and abundance of water-based recreational opportunities that are supported by the DHES reservation provide the base for a highly diverse, environmentally-sensitive industry in the Missouri Basin. The amenities that would be protected by the reservation directly support water-based recreational businesses and also attract tourists, "distance-independent" businesses and people with independent incomes. Collectively, all of these businesses and income sources comprise an amenity-based, growth-oriented industry that is essential to the continued growth and prosperity of the basin.

### 3. Agriculture

Existing agricultural water right holders would benefit from the DHES reservation because of increased legal and physical assurances about future delivery and supply of water for their crops and livestock. Although the long-term stability that would be provided to these landowners has not been quantified economically, it would be substantial as far as its influence on property values, crop production rates and reductions in legal costs which may arise from disputes between junior and senior water users. However, since no firm monetary data exist for these economic benefits, they have been incorporated into the discussion about non-economic benefits of the reservation (II.2.c).

## III. Effects of the Reservation on the Environment, Public Welfare and Safety

### A. An Overview of Indirect, Non-Economic Benefits

The scenic and recreational values of rivers are largely a function of their water quantity (instream flows), water quality and riparian areas. As has been previously discussed, the DHES reservation would help preserve these attributes, which are vital components of the Missouri Basin's natural environment. In fact, all direct benefits of the reservation are also indirect benefits to the environment, since the DHES is a public agency charged with the maintenance, protection and enhancement of water quality for all beneficial uses.

However, protection of the natural environment through adequate instream flows does far more than just preserve hydrologic conditions and biological abundance. It also benefits the human environment as well as the public's health, welfare and safety. A discussion of these benefits is presented in the Department of Fish Wildlife and Parks reservation request and will not be repeated here.

In the sections that follow, other indirect non-economic benefits of the reservation to other uses or parties are described. It is important to note that there are no indirect, non-economic costs of the reservation to the environment, public health, welfare or safety.

## B. Non-Economic Benefits to Other Users or Parties

### 1. Municipalities

The instream flows requested in the DHES reservation would continue to enhance the human environment for residents of municipalities of the Missouri Basin. Adequate streamflows would help enhance the visual attributes of river bottom lands by keeping riparian plant communities healthy and viable and by providing habitat for wildlife and birds that residents enjoy observing. The attractiveness of a stream is also closely tied to its water level. Discharge levels below those requested in this application would lead to increases in exposed (dewatered) channel reaches as well as decreases in total living space available for fish and other aquatic life. The reservation would help preserve both the volume and surface area of streams, thereby perpetuating sport fishing and, where presently conducted, river floating opportunities. These amenities are substantial and irreplaceable social, aesthetic and recreational benefits of the reservation to citizens of municipalities that border flowing streams. The opportunity to fish, float or swim in the streams, observe wildlife and birds, or to simply enjoy the serenity of sparkling waters beneath the shade of cottonwoods in a city park, contribute immeasurably to the quality of life in these communities.

A major public health benefit of the DHES reservation is its role in protecting municipal water supplies. Many municipalities in the Missouri Basin utilize surface water or shallow, streamside aquifers as their drinking water sources. The reservation would help maintain stream discharge levels necessary to dilute the harmful effects of hazardous materials (in addition to arsenic) and microbial organisms that enter these streams. Some herbicides and pesticides that are used by farmers, ranchers, weed districts, and on urban gardens and lawns are quite persistent (slow to decompose) in the environment. Leaks, spills or improper

application, storage and disposal of these chemicals result in contaminated surface and groundwaters. Unless adequate dilution is available, concentrations of these substances in public water supplies can reach levels harmful to human health.

2.1

## 2. Industry

The two largest hydroelectric dams on the Missouri River in Montana, Canyon Ferry and Fort Peck, are operated by the federal government. Maintaining instream flows will benefit public welfare by assuring reliable water delivery for power generation at these federal facilities.

Many headwater trout streams in the Missouri Basin are presently impaired by discharges of acid and toxic metals from abandoned mining operations, e.g., the upper Wise River, Boulder River, Prickly Pear Creek (near Helena), Belt Creek (near Great Falls), Grasshopper Creek (near Bannack), and others. Reduction in instream flows would reduce the capacity of these streams to dilute the discharges, causing toxicity problems to spread farther downstream. This would result in degradation of more miles of viable fishing streams.

## 3. Agriculture

Regardless of the amount of water apportioned for instream flow reservations, existing water rights in the basin would at all times be honored. In fact, if the DHES' reservation is granted, existing water users would be provided with additional assurances of future surface and groundwater availability. Reserved instream flows would help maintain water levels at existing headgates and would provide a legal buffer to any future water development plans by new water users. During low flow years, maintenance of existing streamflows would also help ease conflicts between junior and senior water users in the basin.

Instream flows often recharge shallow, alluvial groundwater tables that adjoin rivers and streams. Maintenance of these vital groundwater systems provides additional benefits to agriculture.

The riparian vegetation that is supported by shallow groundwater, e.g., willows, cottonwoods, birch and aspen, all have extensive root systems

that stabilize streambanks and channels. The soil stability provided by healthy, well-managed riparian areas not only prevents erosion, but also reduces potential flood damage to crops and farm buildings.

In many valleys of the upper basin, moist meadows and other riparian-like areas are often used to grow alfalfa and hay crops, or as highly productive pasture lands. Many of these sites are "sub-irrigated" by shallow water tables that are recharged by surface water. The DHES reservation would help maintain these moist growing sites. New diversions could reduce essential recharge which could reduce the forage productivity of these existing agricultural lands.

Finally, streamside aquifers are often utilized as domestic, livestock or irrigation water supplies. The reservation would help sustain existing water table levels, and thereby, the availability and/or quantity of these shallow groundwater supplies.

#### IV. Economic Opportunity Costs of the Reservation

##### A. An Overview of Indirect Economic Costs

Agriculture is by far the largest offstream consumptive water user in Montana, accounting for approximately 97.6% (15.41 million acre-feet) of the water diverted. In the Missouri Basin in Montana, agriculture accounts for an even larger share of the water diverted by consumptive users--approximately 99% (7.99 million acre-feet). Of this diverted water, about 22% (1.76 million acre-feet) is actually consumed (DNRC, 1986). Loss of water to the atmosphere from reservoir surfaces likely results in a nearly equal amount of water consumption in the basin. Estimates for reservoir evaporation losses specific to the Missouri Basin were not presented in the 1986 DNRC report. However, on a statewide basis in 1980, evaporation from reservoirs was estimated to account for 53.8% of all water consumption in Montana, while agricultural users consumed 44.6% for irrigation purposes.

In the Missouri Basin in Montana, use of surface water by municipalities and industry is relatively minor--about 1% of total water consumption. During 1980, 0.071 million acre-feet of water was diverted for municipal use, but only 0.025 million acre-feet was consumed. Water withdrawals for industry-owned water supplies were even less, amounting to 0.003 million

acre-feet in 1980 (MDNRC, 1986). Even when the more highly populated and industrialized middle Missouri River states are included in these figures, non-agricultural uses are still relatively insignificant, amounting to less than 4% of the water consumed in the entire ten-state basin (O'Keefe, et al. 1986).

Agricultural uses of water are primarily for irrigation and to a lesser extent, for stock watering. Industrial uses include mining (placer and ore processing), manufacturing (process and cooling water) and hydropower. Municipal use is primarily for public water supplies.

## 2. Economic Costs to Other Uses or Parties

### a. Municipalities

Future water demands for municipalities are difficult to predict because of problems associated with growth projections for cities and towns and uncertainties about the cost-effectiveness of surface water supplies in the future. Recent outbreaks of giardiasis in Bozeman and other smaller communities in the basin have prompted the need for additional treatment of surface drinking water supplies. *Giardia* cysts are not destroyed by conventional water treatment methods. Filters, which are large, costly and difficult to operate and maintain, are presently the most commonly prescribed treatment for removing the minute cysts.

Giardiasis is spread by mammalian feces. During the past decade, its incidence has increased dramatically in surface waters of the Northern Rockies. Because of the giardiasis outbreak and other water quality considerations, the 1986 Amendments to the Federal Safe Drinking Water Act require that all surface drinking water supplies be subjected to additional filtration requirements by the early 1990s. Treatment costs for surface drinking water sources will, therefore, inevitably increase, which will decrease the economic attractiveness of these sources for future drinking water supplies.

Presently, 5 municipalities in the upper Missouri River Basin are planning to supply more water for commercial, residential, and industrial needs by the year 2025 (HKM Associates, 1987). Three of the communities (Dillon, Three Forks and Belgrade) plan to obtain the needed water from wells, whereas West Yellowstone and Bozeman will supplement their water supply from surface waters.

West Yellowstone plans to pump 2,550 acre-feet per year from Whiskey Springs at a rate of 1,582 gallons per minute (gpm) by the year 2025. Bozeman predicts that it will need an additional 4,030 acre-feet per year to supplement groundwater sources and water available from Hyalite Reservoir. Bozeman plans to construct a dam on Bozeman Creek to provide the water required by the year 2025.

Granting of instream flow reservations could

conflict with the needs of Bozeman for additional water. Instream flow reservations could also affect West Yellowstone's proposed project. However, such affect would depend on which tributaries were selected to supply the flows which are being requested downstream. Instream reservations could event conflict with those communities obtaining additional water from wells.

b. Industry

Within the 10-state Missouri River Basin, the largest industrial use of water is for thermoelectric power generation; in 1978, 0.443 million acre-feet of water was diverted for the cooling water needs of coal-fired plants (O'Keefe et al. 1986). However, there are no thermoelectric plants in the portion of the Missouri Basin covered by this reservation request, and, even if there were, the water needs would be relatively minor. For example, water withdrawals for the seven coal-fired electric plants in the Yellowstone Basin amounted to 0.094 million acre-feet in 1980, but only about 10% of this water was actually consumed (DNRC, 1986). As well, if any coal-fired plants were to be built near Fort Peck Reservoir, water would be available for lease pursuant to authority granted by the 1987 Montana Legislature (HB 608).

Mining and processing of mined products is an important industry in the Missouri River Basin in Montana. Currently, there are approximately 36 active mining operations in the basin that have been issued permits by the Montana Department of State Lands (DSL) for the mining of talc (5 permits), gold (16 permits), limestone (5 permits), gypsum (2 permits), silica/quartz (6 permits), iron (1 permit) and chlorite (1 permit) (Table 11).

Table 11. Operating Mines Permitted by the Department of State Lands in the Missouri River Basin.

Company	County	Stream Drainage	Product	Process
Mt. Heagan Development Inc.	Jefferson	Boulder River	Gold	Cyanide Heap
Leach Searle Bros. Construction, Inc.	Beaverhead	Horse Prairie Cr	Gold	Placer
S and G Mining	Jefferson	Boulder River	Gold	Placer
Browns Gulch Mining	Madison	Alder Gulch	Gold	Placer
RLTCO	Beaverhead	Grasshopper Crk	Gold	Placer
Golden Sunlight Mine	Jefferson	Jefferson River	Gold	Cyanide Leaching
Vat				
Golden Star Mine	Beaverhead	Big Hole River	Gold	Placer
Continental Lime Inc.	Jefferson	Indian Creek	Limestone	Quarry
Hemphill Bros. Inc.	Jefferson	Boulder River	Quartz	Quarry
Stauffer Chemical Co.	Beaverhead	Big Hole River	Quartz	Quarry
Ideal Basic Ind	Gallatin	Missouri River	Limestone	Quarry
Cyprus Industrial	Madison	Madison River	Talc	Mine
Cyprus Industrial	Madison	Madison River	Talc	Mine
Cyprus Industrial	Beaverhead	Beaverhead River	Talc	Mine
Pfizer Inc.	Beaverhead	Beaverhead River	Talc	Mine
Willow Creek Talc	Madison	Ruby River	Talc	Mine
Cyprus Industrial	Jefferson	Jefferson River	Chlorite	Mine
Spotted Horse	Fergus	Spotted Horse Gulch	Gold	Cyanide Leach
Pauper's Dream	Lewis & Clark	Ten Mile Creek	Gold	Cyanide Leach
Pegasus	Phillips	Ephemeral Drainage	Gold	Cyanide Leach

Montana Tunnels	Jefferson	Spring Creek	Gold	Cyanide Leach
Mortenson Const.	Cascade	Missouri River	Gravel	Quarry
Intergem	Meagher	Missouri River	Iron	Open Pit
Walter Savoy	Cascade	Sun River	Rip-rap	Quarry
Chouteau County	Chouteau	Teton River	Rock	Quarry
Ash Grove Cement	Jefferson	Prickly Pear Crk	rip-rap	
U.S. Gypsum	Jefferson	Prickly Pear Crk	Limestone	Quarry
Maronick Const.	Judith	Judith River	Gypsum	Quarry
	Basin		Gypsum	Quarry
Maronick Const.	Jefferson	Prickly Pear Crk	Limestone	Quarry
Special Lady	Lewis & Clark	Ten Mile Creek	Gold	Placer
St. Joseph	Lewis & Clark	Ten Mile Creek	Gold	Placer
Gulf-Titanium	Lewis & Clark	Little Prickly Pear Creek	Gold	Cyanide Leach
AMAX	Judith Basin	Judith River	Gold/ Silver	Cyanide Leach
Kendall Venture	Fergus	Judith River	Gold	Cyanide Leach
Pacific Silica	Jefferson	Prickly Pear Crk	Silica	Quarry
Indian Creek	Jefferson	Indian Creek	Limestone	Quarry

Source: Montana Department of State Lands, Helena, Montana.  
Permit Application Files (November 1988)

The existing gold mines are primarily placer mines which are non-consumptive water users, and mines which extract gold through cyanide leaching of ore. Quartz and limestone are quarried for the production of cement, the processing of which consumes no water except for domestic purposes (i.e., drinking water and wastewater treatment). Talc, gypsum and chlorite mines consume little or no water in mining and processing.

Prospective gold mines have permits pending in the upper Missouri River Basin. The AGAU/Montoro Joint Venture in the Rattlesnake Creek drainage near Argenta proposes to process ore through cyanide heap leaching. The Yellowband Mine, also near Argenta, would process gold and silver ore through a flotation mill.

New gold and silver mines probably would be the largest future industrial consumers of water in the Missouri River Basin in Montana. To estimate the amount of water that might be needed by future mines, water use by existing mines in Montana has been determined (Table 12). Water use for 13 mines obtaining water from both surface and groundwater sources was 6,882.6 gpm for processing 208,400 tons of ore. Average water use was 529.4 gpm and average ore production was 16,031 tons per day (an average of 1 gpm is required to process 30 tons of ore per day).

Water use and production for mines obtaining water from surface sources (Table 13) was compared with water use and ore production for mines obtaining water from groundwater sources (Table 14). Mines obtaining water from surface sources processed a total of 57,850 tons of ore per day and used 2,197,440 gallons of water per day (1 gpm to process 38 tons/day). Mines obtaining water from groundwater sources processed 150,550 tons of ore per day and used 6,825,600 gallons of water per day (1 gpm to process 31.8 tons/day). Approximately 72% of the ore mined was processed utilizing groundwater.

Table 12. Water Requirements, Water Sources, and Production of Permitted Precious Metal Mines in Montana.

Mine	Ore Production		Water Consumption		Water Source
	County	(tons/day)	(gpm)		
Spotted Horse	Fergus	50	1.6		Discharge from existing adit
Pauper's Dream	Lewis & Clark	1,500	28		Wells
ASARCO-Troy	Lincoln	60,000	1,700		Wells
Pegasus	Phillips	80,000	1,700		Wells
Jardine	Park	1,050	300		Bear Creek and Pine Creek
Beal Mountain Creek	Silver Bow	5,500	200		Beef-straight
Chartam	Broadwater	3,000	300		Wells
CoCa	Flathead	5,000	660		Wells
Black Pine	Granite	1,000	5		South Fork Lower Willow Creek
Montana Tunnels	Jefferson	15,000	918		600 to 900 gpm from Spring Creek, Prickley Pear Creek, and Clancy Creek, 90 gpm from adits
Golden Sunlight	Jefferson	35,000	700		Jefferson Slough
Mt. Heagan	Jefferson	300	20		Slaughterhouse Gulch Creek
Stillwater	Stillwater	<u>1,000</u>	<u>350</u>		Mine workings & wells
Total		208,400	6,882.6		
Average		16,031	529.4		
1 gpm to process 30.3 tons/day					

Source: Montana Department of State Lands, Helena, Montana. Permit Application Files (November 1988).

Note: All of these mines are not in the Missouri River Basin.

Table 13. Ore Production and Water Requirements for Permitted Precious Metal Mines Obtaining Water from Surface Sources in Montana.

Mine	County	Ore Production (tons/day)	Water Consumption (gpm)	Water Source
Jardine	Park	1,050	300	Bear Creek and Pine Creek
Beal Mountain	Silver Bow	5,500	200	Beefstraight Creek
Black Pine	Granite	1,000	5	South Fork Lower Creek
Willow				
Golden Sunlight	Jefferson	35,000	700	Jefferson Slough
Mt. Heagan	Jefferson	300	20	Slaughterhouse Gulch Creek
Montana Tunnels	Jefferson	<u>15,000</u>	<u>300</u>	Spring Creek
Total		57,850	1,525	
Average		9,642	254	
1 gpm to process 38 tons/day				

Source: Montana Department of State Lands, Helena, Montana, Permit Application File (November 1988).

The impact that water reservations would have on future mining development in the Missouri River Basin would be related to the number of new mines opened and the water sources used to process ore. Estimating the numbers of mines that would open is speculative given the volatile nature of precious metals prices. Typically, gold and silver mining follow "boom and bust" cycles. Although mining in Montana may currently be expanding, it is not possible to predict whether this trend will continue.

According to McCulloch et al. (1988), gross production in 1988 from metal mines in Montana was up 45% from the previous year. The number of new or renewal exploration permits issued by DSL also increased from 56 in 1982 to 111 in 1987 and 192 in 1988 (McCulloch et al. 1988). Although it is speculative to predict future precious metal mining activities in the Missouri River Basin, a 7-year trend of wages and salaries paid to miners in the Missouri River Basin was tabulated for 1981-87 (Table 15). As shown in Table 16, mining in the Missouri River Basin provided 41.2% of salaries and wages paid throughout the state for metal mining in 1987. Wages and salaries increased in the upper Missouri River Basin from \$2,392,000 in 1981 to \$11,937,000 in 1987. In the lower Missouri River Basin, wages and salaries increased from \$4,359,000 in 1981 to \$7,876,000 in 1987.

Table 14. Water Requirements and Production for Permitted Precious Metal Mines Obtaining Water from Groundwater Sources in Montana.

Mine	County	Ore Production (tons/day)	Water Consumption (gpm)	Water Source
Pauper's Dream	Lewis & Clark	1,500	28	Wells
Spotted Horse	Fergus	50	1.6	Discharge from existing adit
ASARCO-Troy	Lincoln	60,000	1,700	Wells
Pegasus	Phillips	80,000	1,700	Wells
Chartam	Broadwater	3,000	300	Wells
CoCa	Flathead	5,000	660	Wells
Stillwater	Stillwater	<u>1,000</u>	<u>350</u>	Mine workings
Total		150,550	4,739.6	
Average		21,507	677	
1 gpm to process 31.8 tons/day				

Source: Montana Department of State Lands, Helena, Montana. Permit Application Files (November 1988).

Table 15. Wages and Salaries from Metal Mining in the Upper and Lower Missouri River Basin (thousands of dollars).

Year	<u>Lower Missouri River Basin</u>		<u>Upper Missouri River Basin</u>	
	State Total	Wages/Salaries	Percent of State Total	Percent of Wages/Salary
1987	\$48,078	\$7,876	16.4%	\$11,937 <sup>1</sup>
1986	33,944	4,928	14.5	5,760
1985	26,812	3,392	12.6	5,091 <sup>2</sup>
1984	32,988	6,737	20.4	4,864 <sup>3</sup>
1983	44,683	4,311	9.6	6,044
1982	52,448	3,406 <sup>4</sup>	6.5	2,307
1981	57,756	4,359 <sup>5</sup>	7.5	2,392
Average	\$42,387	\$5,001	11.8%	\$ 5,485

Source: Montana Department of Labor and Industry, Montana Employment, Wages, and Contributions, Annual Average 1981-87.

- <sup>1</sup> Excludes Broadwater County for purposes of confidentiality.
- <sup>2</sup> Excludes Beaverhead County for purposes of confidentiality.
- <sup>3</sup> Excludes Gallatin County for purposes of confidentiality.
- <sup>4</sup> Excludes Meagher County for purposes of confidentiality.
- <sup>5</sup> Excludes Cascade County for purposes of confidentiality.

Fairly reliable estimates of the remaining precious metals resources in the Missouri River Basin can be derived by examining past mining activities in the basin because future mining is predicted to occur where mining has historically taken place (Webster, 1988). New mining and ore processing technologies have made it economically feasible to extract metals from ore bodies that were previously not mined. According to Hahn (1988), minimum reserves of gold and silver in Montana are 8,012,000 and 617,165,000 ounces, respectively. Historic production of gold and silver in Montana was 20,396,000 and 950,253,000 ounces, respectively. The ratio of present estimated metal reserves to past production is 1:2.5 for gold and 1:1.5 for silver. If the estimated reserves of gold are correct, there are approximately .40 ounces of gold reserves for every ounce that already has been mined. Similarly, there are approximately .67 ounces of silver reserves for each ounce that has been mined.

To obtain an estimate of gold and silver reserves in the Missouri River Basin, historic gold and silver production was tabulated for mining districts in the basin (Table 16).

Approximately 57% of all gold and 16% of all silver mined in the state came from mining districts in the Missouri River Basin. Assuming that the ratio of reserves to mined production is 1:2.5 for gold and 1:1.5 for silver, there would be approximately 4,691,440 ounces of gold reserves and 100,224,342 ounces of silver reserves remaining in historic mining districts in the Missouri River Basin. Approximately 28% of the original reserves of gold and 40% of the original reserves of silver remain to be mined in the Missouri River Basin, provided new technologies allow for cost-effective extraction of these metals.

Table 16. Historic Extraction of Gold and Silver in the Missouri River Basin.<sup>1</sup>

Mining District	County	Production (ounces)	
		Gold	Silver
Argenta	Beaverhead	64,400	562,000
Bannack	Beaverhead	387,000	141,000
Bluewing	Beaverhead	500	
470,000			
Bryant	Beaverhead	17,400	
13,924,000			
Elkhorn	Beaverhead	2,000	
387,000			
Polaris	Beaverhead	300	
120,000			
Vipond	Beaverhead	1,100	
1,025,000			
Confederate Gulch	Broadwater	650,000	
7,570			
Park	Broadwater	120,000	
394,000			
Radersburg	Broadwater	325,000	
311,000			
Winston	Broadwater	118,000	
2,058,000			
Neihart	Cascade	67,000	
29,070,000			
North Moccasin	Fergus	450,000	
50,000			
Warm Springs	Fergus	335,00	
317,000			
Alhambra/Basin	Jefferson	15,400	
118,000			
Boulder	Jefferson	4 8 0 , 0 0 0	
14,770,000			
Clancy	Jefferson	140,000	
2,500,000			
Elkhorn	Jefferson	100,000	
12,600,000			
Whitehall	Jefferson	563,000	
277,000			
Wickes	Jefferson	372,000	
47,700,000			
Barker	Judith Basin	3,500	
2,738,000			
Gould/Stemple	Lewis & Clark	345,000	
500,000			
Heddleston	Lewis & Clark	--	
1,409,000			
Lincoln	Lewis & Clark	682,000	
120,000			
Marysville	Lewis & Clark	1,390,000	
8,880,000			

York	Lewis & Clark	335,000	--
Rimini/Scratchgravel	Lewis & Clark	100,000	
100,000			
Norris	Madison	265,000	
102,000			
Pony	Madison	346,000	
227,000			
Renova	Madison	162,000	
113,000			
Sheridan	Madison	40,000	
105,000			
Silver Star	Madison	225,000	
152,000			
Tidal Wave	Madison	33,400	
133,000			
Virginia City	Madison	2,617,000	
1,456,000			
Washington	Madison	16,600	
42,000			
Castle Mountain	Meagher	--	
4,270,000			
Little Rockies	Phillips	<u>960,000</u>	
<u>2,440,000</u>			
Total		11,728,600	
149,688,570			
State Total		20,396,000	
950,253,000			
Percent of State Total		57.5%	15.7%

Source: Hahn 1988. Gold and Silver Districts in Montana.

<sup>1</sup> Only mines which have produced more than 10,000 ounces of gold or more than 100,000 ounces of silver are listed.

Basing future metals production in the Missouri River Basin on past statewide production (as just discussed) may underestimate the future metals reserves in the basin. Data for "proven" gold and silver reserves in the basin as of January 1989 (Hahn, 1989) are shown in Table 17. (Proven reserves are silver and gold deposits that have been measured by actual exploration methods. It is assumed that metals from these ore bodies could be economically extracted at 1988 metals prices.) Assuming that both the statewide metals reserves and the Missouri River Basin proven reserves are correct, proven gold reserves in the basin would be 91% of the total state reserves. Similarly, the proven silver reserves in the basin would be 34% of the total state reserves.

Reservations of instream flows in the Missouri River Basin would have no impact on existing mining or new mines utilizing groundwater, but they could affect future mining and ore processing.

Table 17. Proven Gold and Silver Reserves in the Missouri River Basin.

<u>District</u>	<u>Gold Reserve</u>	<u>Silver Reserve</u>
Winston	360,000	--
North Moccasin	60,000	--
Warm Springs	24,000	175,000
Elkhorn	500,000	--
Whitehall	2,500,000	2,500,000
Wickes	2,520,000	23,660,000
Lincoln	103,000	120,000
Marysville	50,000	--
Rimini	270,000	--
Jardine	330,000	--
New World	100,000	--
Little Rockies	<u>500,000</u>	<u>7,750,000</u>
Total	7,317,000	34,205,000

Source: Montana Department of State Lands, Helena, Montana, 1989.

### c. Agriculture

Revenues from agriculture in the Missouri River Basin are nearly equally provided by livestock and crop production. Average cash receipts from crops for the 7-year period (1980-86) contributed approximately 43% of the total state crop revenues (see average values in Tables 18 and 19). Similarly, livestock production in the Missouri River Basin provided about 43% of total state livestock revenues (see average values in Tables 19 and 20).

Irrigated land in the Missouri River Basin comprises about 50% of all irrigated land in the state (Tables 20 and 21). Non-irrigated land in the basin makes up about 43% of all dryland agriculture on a statewide basis (Tables 20 and 21). The upper Missouri River Basin has about 24% of the irrigated land in the state (Table 20), whereas the lower basin has approximately 25% of the State's irrigated land (Table 21). The lower basin differs from the upper basin primarily in the amount of dryland farming. The lower basin has about 40% of the dryland agriculture in the state compared with only 2.4% of the total state dryland farming in the upper basin.

Instream water reservations would not affect existing agricultural use in the basin. Reservations could limit future expansion of irrigated agriculture if new water sources are needed. However, even the maximum potential cost of the DHES Reservation to new irrigated crop acreage in the upper Missouri Basin would be relatively small. Sanders (1989) provided a higher estimate for the number of existing irrigated acres in the upper basin (622,250 acres) than is displayed in Table 20 (407,896 acres). As of March 24, 1989, the Jefferson Valley, Broadwater and Gallatin Conservation Districts had submitted reservation requests for surface water irrigation of 23,925 additional acres upstream from Canyon Ferry Reservoir (Sanders, 1989). If no other reservation applications for agricultural surface water diversions are submitted by other upper basin conservation districts, the opportunity for growth in irrigated agriculture in the upper basin would essentially be limited to a 3.6% to 5.9% increase over existing acres. The potential cost that the DHES reservation could have upon agriculture above Canyon Ferry would, therefore, be to inhibit this relatively small increase in total irrigated acreages.

In the lower Missouri Basin, irrigated acreage estimates by Sanders (334,250 acres) were lower than those in Table 21 (425,319). As of March 24, 1989, information was not available regarding reservation requests by Conservation Districts in the lower basin. DNRC is currently compiling these figures, while refining estimates of existing and potentially irrigable lands throughout the basin.

Table 18. Livestock and Crops Cash Receipts in the Upper Missouri River Basin 1/ (thousands of dollars).

Year	Livestock Receipts	State Total	Percent of State Total	Crop Receipts	State Total	Percent of State Total
1986	\$119,700	\$838,353	14.3%	\$37,385	\$493,015	7.6%
1985	124,522	902,859	13.8	42,639	422,444	10.1
1984	114,022	844,683	13.5	34,684	653,780	5.3
1983	98,651	731,537	13.5	44,893	846,939	5.3
1982	88,667	724,805	12.2	60,714	980,328	6.2
1981	86,218	705,528	12.2	53,007	854,196	6.2
1980	98,470	828,880	11.9	41,102	660,450	6.2
Average	\$104,321	\$796,663	13.1%	\$44,918	\$701,593	6.4%

Source: Montana Crop and Livestock Reporting Service.

1/ Includes Beaverhead, Broadwater, Gallatin, Jefferson, and Madison counties.

Table 19. Livestock and Crops Cash Receipts in the Lower Missouri River Basin. 1/ (thousands of dollars).

<u>Year</u>	<u>Livestock Receipts</u>	<u>State Total</u>	<u>Percent of State Total</u>	<u>Crop Receipts</u>	<u>State Total</u>	<u>Percent of State Total</u>
1986	\$241,741	\$838,353	28.8%	\$184,082	\$493,015	37.3%
1985	272,147	902,859	30.1	136,036	422,444	32.2
1984	248,880	844,683	29.5	252,933	653,780	38.7
1983	215,725	731,537	29.5	328,134	846,939	38.7
1982	228,313	724,805	31.5	355,893	980,328	36.3
1981	222,745	705,528	31.6	311,016	854,196	36.4
1980	261,051	828,880	31.5	240,195	660,450	36.4
Average	\$241,515	\$796,663	30.3%	\$258,327	\$701,593	36.8%

Source: Montana Crop and Livestock Reporting Service.

1/ Includes Cascade, Chouteau, Fergus, Glacier, Judith Basin, Lewis and Clark, Meagher, Phillips, Pondera, Teton, Toole, Petroleum, Wheatland, Golden Valley, Musselshell, and Garfield counties.

Table 20. Irrigated and Non-irrigated Land in the Upper Missouri River Basin. 1/

Year	Irrigated	Percent of state		Non-irrigated	Percent of state	
		Total	Total		Total	Total
1987	360,770	1,618,500	22.3%	201,400	7,623,000	2.6%
1986	344,470	1,601,000	21.5	175,000	7,814,200	2.2
1985	428,830	1,635,200	26.2	171,500	5,977,500	2.8
1984	481,300	1,805,600	26.7	164,400	7,377,400	2.2
1983	395,700	1,538,900	25.7	220,700	7,151,400	3.1
1982	417,850	1,729,900	24.1	155,400	7,926,200	2.0
1981	426,350	1,733,300	24.6	144,000	7,932,600	1.8
Average	407,896	1,666,057	24.5%	176,057	7,400,329	2.4%

Source: Montana Crop and Livestock Reporting Service.

1/ Includes Beaverhead, Broadwater, Gallatin, Jefferson, and Madison counties.

Table 21. Irrigated and Non-irrigated Land in Lower Missouri River Basin. 1/

Year	Irrigated	Percent State of State		Non-irrigated	Percent State of State	
		Total	Total		Total	Total
1987	410,150	1,618,500	25.3%	3,121,000	7,623,000	40.9%
1986	429,280	1,601,000	26.8	3,207,900	7,814,200	41.1
1985	382,500	1,635,200	23.4	2,367,800	5,977,500	39.6
1984	462,700	1,805,600	25.6	3,141,500	7,377,400	42.6
1983	405,400	1,538,900	26.3	2,959,100	7,151,400	41.4
1982	460,400	1,729,900	26.6	3,105,100	7,926,200	39.2
1981	426,800	1,733,300	24.6	3,097,100	7,982,600	38.8
Average	425,319	1,666,057	25.5%	2,999,929	7,407,471	40.5%

Source: Montana Crop and Livestock Reporting Service.

1/ Includes Cascade, Chouteau, Fergus, Glacier, Judith Basin, Lewis and Clark, Meagher, Phillips, Pondera, Teton, Toole, Petroleum, Wheatland, Golden Valley, Musselshell, and Garfield counties.

## V. Effects of Not Granting the Reservation

### A. Irretrievable increase in excess cancer risks and contamination of soils and crops.

Not granting the DHES reservation would cause irretrievable increases the arsenic concentrations of the Madison and Missouri rivers and contamination of soils and crops. Incremental streamflow depletions would continue to increase arsenic concentrations, and increase the areas in which arsenic concentrations would be increasing in crops and soils. This, in turn, could reduce the marketability of irrigated crops.

Long-term economic costs would be significant if instream flow depletions were to continue in the Missouri River Basin. The brunt of these losses would be borne by individuals and the families of those who contract cancer as a result of arsenic exposure. Additional costs will result if or when arsenic concentrations in crops reach the point at which these crops can not be sold for human consumption in interstate commerce.

Additional costs would result from a reduction in streamflow-dependent recreational businesses and the cities and towns that receive the benefits of these enterprises. However, since the recreational and scenic attributes and the pure water that attract people to the basin would also diminish, these municipalities would also sustain other economic opportunity losses (i.e., being less attractive to distance-independent companies, tourists and new potential residents with independent incomes). Services sector jobs would also be impacted. Not granting the DHES flow reservation would preclude a unique opportunity to support and protect, collectively, the public interest, the environment and business interests. Denial of the reservation would be particularly incongruous at a time when the newly established "bed-tax" is beginning to fund multi-million dollar, nationwide advertising campaigns for recreational and service sector businesses, and local economic development organizations like the Gallatin Development Corporation are beginning to attract new kinds of businesses to the Missouri Basin.

Without instream protection, other significant benefits to municipalities, agriculture and industry would also be diminished. New consumptive uses of water would continue to reduce downstream water availability and hydropower production. The recharge of streamside aquifers, the assimilative capacity of streams and the viability of riparian ecosystems and sub-irrigated croplands would be diminished. Industrial and municipal waste treatment costs

could increase. The potential for contamination of public drinking water supplies by hazardous chemicals in addition to arsenic would become more likely, as would additional impacts to streams receiving mine discharges. Water disputes between consumptive users could worsen as water availability at headgates declines. The effects of not granting the reservation would, therefore, be cumulative, and in many cases irretrievable, to a broad spectrum of resources and water users in the Missouri River Basin.

B. Alternative Actions That Could Be Taken If the Reservation is Not Granted

1. No Action

A no-action alternative regarding water reservations in the Missouri River Basin would result in the same costs to the public health, recreation, fish and wildlife, economics, aesthetic qualities and other public amenities that were just described in the Effects of Not Granting the Reservation. Other alternative actions that could possibly be taken to protect the public health and the other amenities and economic assets are described below. These alternatives either are more costly, would be less immediate, lack legislative mandates and/or would be more limited in applicability, than would granting the DHES reservation as requested in this application.

2. Intensification of Water Conservation and Management Practices on Good Quality Tributaries

Examples of water conservation practices include better maintenance and lining of ditches, converting irrigation projects from flood to sprinkler systems, limiting the use of sprinklers during windy periods and, diverting only the amount of water actually needed for proper crop production. The latter involves installation and/or better management of water diversion and delivery systems, including improved operation and use of headgates and flumes to accurately measure water delivered to users; better information and education about water needs for specific crops throughout the basin's widely varying soil, climatic and topographic conditions; better irrigation scheduling; and increased utilization of water commissioners.

Proper water conservation and management practices not only enhance water efficiency, they also reduce soil erosion by preventing overland (sheet) runoff from croplands and minimizing volumes of silt-laden irrigation return flows. As such, application of the above measures should be encouraged regardless of any other legal directions elected during this reservation process.

Although worthwhile and necessary, good water conservation and management practices do not represent a viable alternative to reserving instream flows. In many instances, any water conserved, and thus left instream, may simply be diverted by other offstream users. Even if the state were to offer to pay for the infrastructure necessary to improve efficiency in agricultural water use which, in turn, would reduce offstream diversion rates and theoretically increase instream flow levels, there is presently no legal method for a public agency to claim or protect water acquired in this manner. This same legal obstacle is also a deterrent to the buying or leasing of water rights.

### 3. Buying or Leasing of Water Rights

A state agency's ability to protect instream water rights that have been converted from offstream rights through leases, gifts, purchases or improved conservation measures has been severely hampered by a recent court decision involving a water right claim for Bean Lake. The lower court ruled that the pre-1973 claim by DFWP for instream use was invalid because the agency never diverted or impounded the water, never demonstrated an intent to claim the water right or gave notice to other water users of that intent. Upon appeal by DFWP, the State Supreme Court recently upheld the lower court's ruling. Unless the legislature permanently removes the diversion requirement for claiming instream water rights, the leasing or buying of water is not a valid alternative to the reservation of instream flows.

This is particularly unfortunate for streams tributary to the Madison River where the arsenic problem is severe. If the present water users on these streams could lease their offstream rights as part of a water conservation program, arsenic concentrations in this stream could be reduced. For example, water users would receive annual lease payments and farm their lands as usual except during low water years. Then, in accordance with lease agreements, normally diverted water would be left instream. The annual lease payments would provide compensation to landowners for any irrigated crop damage suffered during the low flow years. Crop losses could also be reduced if the landowners planted non-irrigated crops on the leased land following years when snowpack is low enough to curtail normal irrigation practices.

Even if, or when, legal obstacles for protecting transferred water rights are removed, the buying or leasing of water would still not be a viable, basin-wide approach for enhancing instream flows. The administration and logistics of such an extensive program would be exceedingly complex, and the cost would be high. This alternative

might, however, be best applied in drainages that are severely dewatered, where present offstream users are willing to sell or lease their rights and where water adjudication proceedings have been completed. The latter condition is very important, since it would be difficult to accurately transfer water rights without precise knowledge of water use and availability in a given drainage.

#### 4. Constructing Offstream Water Storage Facilities

The construction of offstream reservoirs that would store runoff waters and release them during the summer is not a feasible alternative for enhancing instream flows to minimize the affects of arsenic. The risks of excess cancer resulting from arsenic exposure depend on the total dose ingested (EPA, 1988), any depletion, regardless of timing will increase the total arsenic dose to the water consumers. In addition, evaporation from reservoirs will in itself result in an increase in the arsenic concentrations in the Madison and Missouri rivers.

#### 5. Revising the Process for Conditioning Water Rights Permits

For water use applications or transfer of water rights exceeding 4,000 acre-feet per year and 5.5 cfs, MCA 85-2-311 (2)(c) requires that certain "public interest" and "reasonable use" criteria be met before approval to divert the water is granted. Criteria to be evaluated include demands on future water supply; needs to preserve instream flows; benefits to the applicant and the state; effects on water quality, including the potential for creating saline seep; the feasibility of using other (low-quality) water; and consideration of other adverse environmental impacts.

Although the above "conditioning" of water use permits would certainly be helpful for protecting instream flows from large offstream diversions, it does not represent a widely applicable alternative to the water reservation process. Applications for water use that are large enough to trigger utilization of the above criteria are very uncommon. In fact, 80% of all water use permits issued by DNRC since July 1973 have been for quantities less than 1.0 cfs (McKinney, 1988).

To be an effective component of an instream protection strategy, the conditioning of water use permits must, therefore, be revised to include the review of much smaller requests. Instead of an arbitrary volume figure, conditions triggering the use of public interest/reasonable use criteria should instead be guided by the effects of an application upon a given stream's available flow and upon the cumulative basin-wide impacts of all future water

appropriations. Unfortunately, there are few streams in the basin that have enough stream gauging data to document existing available flows. Nor have enough streams in the basin been adjudicated, which makes documentation of existing use extremely difficult.

Finally, even if conditioning of permits were to be revised to incorporate some smaller "triggering criteria," this alternative should only be considered as a supplement to the protection of instream flows through water reservations. Unless conditioning criteria were to be applied to every water use application in the Missouri River Basin (an unlikely situation in the foreseeable future), many "small" water use permits (i.e., those still not surpassing the revised criteria), could continue to be granted without adequate consideration of immediate and cumulative effects upon fish and wildlife uses.

## 6. Closing Basins

Montana water law at MCA 85-2-319 states that DNRC "may by rule reject permit applications or modify or condition permits issued in a highly appropriated basin or sub-basin," but "only upon a petition signed by at least 25% or 10, whichever is less" of present water users in the basin or sub-basin. The petition must allege that throughout or during certain times of the year there are no unappropriated waters in the basin; the rights of present users will be adversely affected; or further uses will interfere unreasonably with other already permitted uses, or uses for which water has been reserved. Upon receiving a petition, DNRC must either deny it, or if needed, conduct a water availability study and initiate rule-making proceedings.

A petition to close the Musselshell River Basin has been submitted to DNRC by the Deadman's Basin Water Users Association. A water availability study is being conducted, and a predictive model is being developed to better examine the concerns raised in the petition and to determine if rule-making proceedings will be necessary.

On March 30, 1983, DNRC closed the Milk River mainstem to any further applications "for direct diversion without storage of waters . . . for irrigation or any other consumptive use." The department acted to close the river (except for some reaches during runoff periods), pursuant to MCA 85-2-321, a legislatively-mandated water availability study and rule making procedure directed specifically at the Milk River Basin.

Both the Musselshell and Milk River proceedings occurred because of concerns raised by existing offstream water users in already "highly appropriated" basins. There is no opportunity in Montana water law for the general

public or state agencies to initiate action to close basins because of instream flow concerns (thereby preventing the over-appropriated conditions occurring in the above basins). By the time closures are initiated and administratively implemented, there may be no water available for instream flow needs. As such, this procedure is not a viable alternative to the timely implementation of instream flow reservations.

#### 7. Encourage or require treatment to remove arsenic

At two public meetings in the Three Forks area DHES has pointed out the potential health effects of arsenic. At both of these meetings DHES suggested that it would be wise to install reverse osmosis or distillation units in each home to provide drinking water. Tests of these some of these units, which have been installed in the area, indicate that they will lower arsenic concentrations from over 100 µg/l to less than 1 µg/l. DHES has estimated that these units cost about \$500 and will provide sufficient amounts of water for drinking water purposes only. Yearly maintenance costs will be about \$200. DHES has as yet made no systematic wide spread effort to determine the magnitude of arsenic contamination of private water supplies. DHES has sampled about 35 private wells distributed from the shores of Hebgen reservoir to the Helena Valley in an attempt to determine if groundwater in other areas has been contaminated by irrigation or by other inputs of river water to the shallow aquifers. This sampling has established that some of the wells have arsenic concentrations nearly the same as the adjacent river values and that some have concentrations exceeding the drinking water standards. The costs of removing arsenic at public water treatment plants have not been estimated but could be very high.

Treatment of drinking water does not completely eliminate arsenic exposure. Arsenic may also be absorbed from water used for laundry or bathing. In addition there could be significant exposure through the consumption of garden produce irrigated with water containing arsenic. DHES plans to investigate this possibility using garden produce from the Three Forks area. Similar investigations should be done to evaluate the possibility of commercial crops accumulating significant amounts of arsenic. Until these studies are performed DHES must assume that arsenic does accumulate to harmful levels in crops.

This alternative will not eliminate the effects of water consumption on arsenic concentrations and the resulting affects on water users. However, this alternative should be pursued regardless of the outcome of the reservation process because it appears to be the only feasible

alternative for the areas where the groundwater is already contaminated.

8. Encourage or require that users switch to alternate water sources

This alternative is not practical because in most cases there are no feasible alternative sources of uncontaminated water.

9. Strict enforcement of Montana water quality laws

Montana law [(85-2-316(6), MCA)], limits the amount of instream flow which the Board of Natural Resources and Conservation (Board) can grant to no more than 50% of the average annual flow (AAF) on gauged streams. Thus DHES can only request the flows which have been listed in which discussed the amount of water requested even though if these flows are granted the number of excess cases of cancer in the basin will potentially double.

Theoretically any reservation or appropriation of water which results in a depletion in the average flow of the Madison or Missouri Rivers will violate the Montana Surface Water Quality Standards (16.20.618 (h) and the Montana Nondegradation Rules (16.20.701 et seq). These two sets of rules taken together prohibit increases in the concentration of substances for which there are drinking water limits and for "deleterious substances" (16,20.618 (h)(i). Arsenic clearly falls in both categories. Since any depletions will cause an increase in the arsenic concentrations in the Madison and Missouri Rivers and will result in an increase in the expected number of cancers in the population which is dependent on these rivers for their drinking water supply any such depletions will violate state law.

While DHES has been considering this option, it has been awaiting action by EPA. EPA has been and is reevaluating the toxic and carcinogenic effects of arsenic. To date EPA has not formally revised it's criteria.

## MANAGEMENT PLAN

ARM 36.16.106(2) states "A management plan shall accompany all reservation applications for instream use(s), as defined in ARM 36.16.102(14), and shall include an explanation of how reserved instream flows will be protected from future depletions by later priority water users."

The following addresses that requirement.

### Monitoring Instream Water Reservations

Implementation of a reservation monitoring/protection program will be an evolutionary process. A water reservation usually obtains a priority date on the day it is granted by the Board and by law cannot affect any existing water users. In the Missouri Basin, the priority date of all reservations has already been established by the legislature as of July 1, 1985. Only subsequent (junior) water use permit holders will be affected. The timing and degree to which DHES will monitor individual streams will depend on the extent of that junior water use. As time passes, streams accumulating the most junior users will be monitored more intensively than those with fewer junior users. As the number of junior users increases and the total effects of those new diversions become more apparent, the monitoring program will be expanded.

Once the reservations in the Missouri basin are granted, mainstem river segments will be monitored from the beginning using established USGS gauges. DHES will monitor applications for new water use permits which will be junior to the reservations if the permit is granted. DHES will notify the applicant, either through a letter or the objection process, that an instream flow reservation exists in the source of supply and that, at some future time, he/she may be asked to cease his water use because of low water conditions. All junior water use permits are conditioned to existing rights at the time the permit is issued, and where DHES objects, the permit should be specifically conditioned to the senior instream flow reservations.

If a drought or low flow year is eminent, DHES will obtain from DNRC a listing current of all water users who are junior to the reservations. An initial letter will be sent to them in June advising them of flow conditions and informing them that they might be subject to a "call" for their junior water. If flow conditions deteriorate and fall below the reservations, DHES will send a second letter to junior users that they must cease their diversions until flows again rise above the reservations. A stream gauge shall be assigned for them to monitor flow levels, and they will be given phone numbers of DHES and the closest DNRC Water Rights Field Office so they can call for flow information.

Shutting off junior users will not always increase flow levels in a drought year and flows may remain below the reservations for the entire irrigation season. DHES realizes its reservations cannot always be met under drought conditions.

Once reservations are granted, the responsibility of DHES to protect those reservations begins. How, when, and where this is done depends on several factors:

1. Need. How many junior water users are there to protect against?
2. DHES Funds Available. Funding levels may vary. DHES' ability to contract with USGS for gauging stations will depend upon the annual availability of these funds.
3. USGS Funds Available. Federal funding levels (USGS matching money) are often uncertain due to budget reduction efforts by the federal government. DHES' ability to contract with USGS will also depend on its level of funding.

A broader base of funding support at the state level would enable a stronger gauging network to be established in the long term and would provide benefits to all Montana water users.

This application was prepared by Abe Horpestad with the assistance of Tom Reid and Dolly Davis. Much of the material in this application is taken from a draft application prepared by the Department of Fish, Wildlife and Parks.

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# APPENDIX A.

MISSOURI RIVER BASIN GAGED FLOWS  
WATER RESERVATION APPLICATION

06/27/89

MONTHLY MEAN AND PERCENTILE STREAMFLOWS FOR SELECTED USGS GAGES (CFS)  
Unpublished Extended Flows -- Base Period 1937-1986

USGS GAGE #	NAME	MONTHLY FLOW DATA	CT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AVERAGE
35	Madison River Below Heppen Lake	MEAN	1340	1260	1270	1289	1214	1111	1015	733	1220	1020	1100	1150	1028
		20th %	1820	180	1820	1830	1851	18100	1400	1170	1840	1260	1220	1420	1356
		50th %	1130	1110	1137	1107	1099	101	1003	102	1000	1010	1060	1200	1002
		80th %	1113	119	111	116	114	1150	104	109	1118	1180	1114	1190	1197
45	Missouri River at Boston	MEAN	4470	4770	4560	430	3770	4070	4670	4780	12300	5080	2620	3500	5193
		20th %	5330	5640	4250	360	4230	4790	7160	11600	17700	7040	3340	4600	6633
		50th %	4410	4670	4300	3400	3750	3340	4570	8720	11900	4580	2380	3410	5047
		80th %	3480	3580	3000	2260	1390	2520	1390	5240	7140	2670	1830	2560	3672
732	Missouri River near Via	MEAN	4830	4250	5150	5260	5230	5700	6830	8780	12800	7260	4310	4260	6409
		20th %	6020	6240	6130	6380	6530	6830	7780	12600	17600	10000	5850	5300	8205
		50th %	4730	4040	4290	5320	5140	5660	6680	8200	11700	6570	4120	4220	6139
		80th %	3650	4210	4510	4210	4350	4490	4180	6570	7190	4020	2740	3070	4408
1395	Missouri River at Virgelle	MEAN	6310	6550	6380	6270	6640	7570	9140	14400	13700	10300	6210	5880	8779
		20th %	7650	7560	7370	7710	8370	9120	12100	18800	26200	14300	8130	7050	11197
		50th %	6140	6390	6450	6950	6650	170	3510	13400	18000	9990	5800	5430	8323
		80th %	4890	5360	5130	4870	5180	5660	6210	9920	11700	5620	4310	4250	6096
1152	Missouri River near Lanousky	MEAN	6790	7260	6350	6690	7310	8930	10100	15500	21700	11500	6780	6360	9631
		20th %	8080	7180	7380	8290	8330	10700	13900	21200	28900	15400	8730	7690	12332
		50th %	6700	6770	6400	6600	7240	8380	9170	14200	19500	11400	6550	5930	9112
		80th %	5340	5300	5590	5130	5460	6530	7000	12200	12300	6210	4700	4590	6629

Source: USGS Extended Flows -- Base Period 1937-1986  
(Unpublished Records)





